

AC Drives for Drilling Applications



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AC Drives for Drilling Applications

Class Requirements

1. Class is from 8:00 a.m. to 5:00 p.m.
2. All Cell Phone must be either turned off or silenced
3. 10 Minute breaks are taken every hour
4. Lunch break is at 11:30
5. If you smoke please stay 20 ft. away from entrances

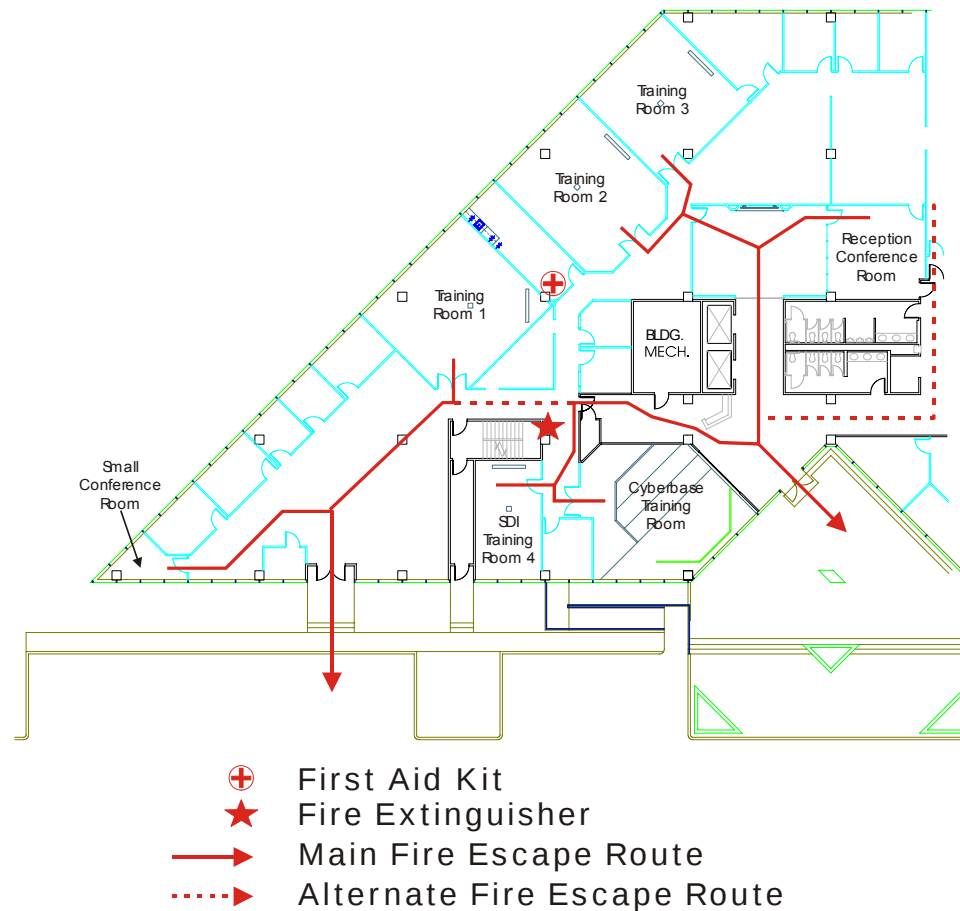
Ask Questions!

Ask Questions!!

Ask Questions!!!

AC Drives for Drilling Applications

Emergency Escape Routes



AC Drives for Drilling Applications

Course Contents

AC Drives

- Types
- Stages
- AC Motor
- Flux Lines
- Bridges

Hardware

- DC Link
- Circuit Boards
- Control Unit
- Modules
- Redundancy
- PLC Networks

Software

- Parameters
- Start Up Data
- Status Parameters
- Configuration Parameters
- Drive Windows
- PLC Control

AC Drives for Drilling Applications

AC Drive History

Cycloconverters

- Small Operating Output Range – Typically 50 – 100%
- Type of Switching Devices - Many
- Electrical Noise Induction was severe
- Power Loss was minimum across the Converter
- Primarily AC to AC Conversion

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AC Drive History

Dual Conversion Current Source

- Input Side was controlled (Similar to the DC Bridges of most Drilling SCR Systems)
- Type of Switching Devices – Primarily SCR, could be GTO*
- High Harmonics (Could be limited with higher pulse bridges)
- Power Loss was Moderate to High across the Converter
- AC to DC to AC Conversion
 - Input Side was typically SCR based (AC to DC)
 - Output Side was either SCR or Darlington based (DC to AC)
- AC Current is what was controlled and monitored most heavily

* Gate Turn Off Thyristor

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AC Drive History

Dual Conversion Voltage Source

- Input Side can be either controlled (SCR Bridge) or constant (Diode Bridge)
- Type of Switching Devices – Primarily IGBT*
- Low harmonics if Diode Bridge used (SCR end can be reduced if higher pulse bridges are used)
- Power Loss is typically High across the Converter
- AC to DC to AC Conversion
 - Rectifier front end was typically Diode Bridge (AC to DC)
 - Inverter back end was either IGBT (DC to AC)
- AC Voltage is what was controlled and monitored most heavily

* Insulated Gate Bipolar Thyristor switching device

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AC Drives

Stages

- Input Side of the Drive is called a Rectifier. Converts the AC Voltage and Current to DC
- Center Section stores energy for Output section. The Rectifier continually feeds this section. The output section draws energy from it as the load requires power.
- Output Section is referred to as the Inverters. Converts the DC power in the center stage to the AC Power used to control the load.
- The output waveform is dictated by the type of switching device used in the Inverter section.
 - SCR based inverter has a square waveform that usually requires a filter on the output to smooth the waveform
 - IGBT based inverter is a PWM (Pulse Width Modulated) waveform that usually requires heavier insulation on the motor windings.

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AC Drives

Middle Stage Storage Device for Dual Converters

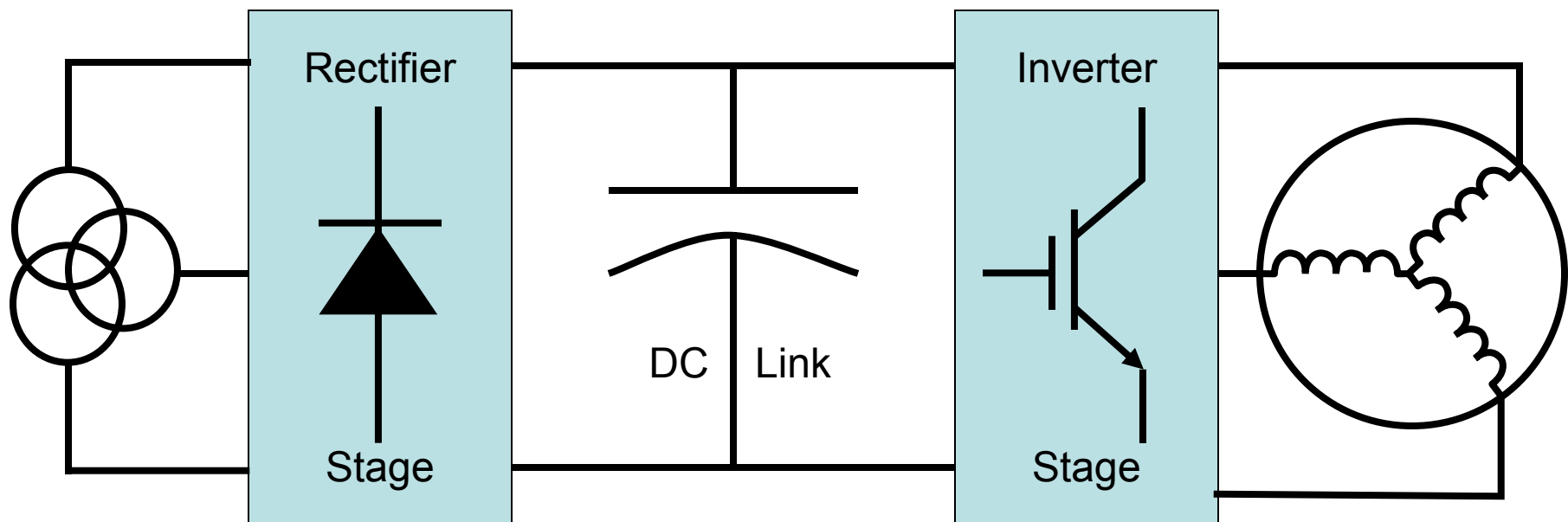
- Some Device needed to store energy for the DC to AC Conversion
- Current Source Drives need a large **Inductor**, Energy was stored in the form of Electromagnetic lines of Flux
- Voltage Source Drives need a large **Capacitor**, Energy was stored in the form of Dielectric Charge
- Lines of Flux would induce the current in the conductor windings of the Inductor
- The Dielectric of the Capacitor would be able to provide the voltage level necessary for the Inverter Device to work, regardless of the current

This center stage is called the DC LINK

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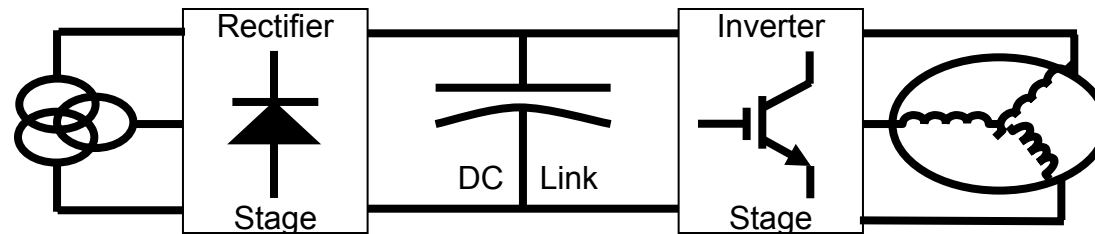
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Block Diagram for Dual Stage Voltage Converters



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AC Drives Rectifier Stage

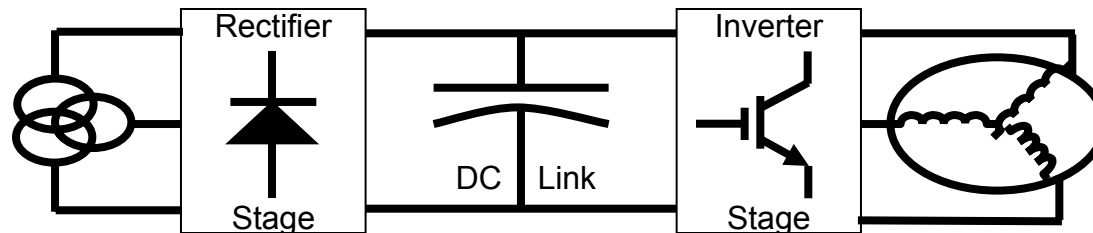


Converts AC Power to DC Power

- Typically “Dumb” – no active controls
- Typically a Diode Bridge
- Fuse or Circuit Breaker protected
- 6 or 12 Pulse Input
- High Power Factor
- Low Losses

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AC Drives DC Link

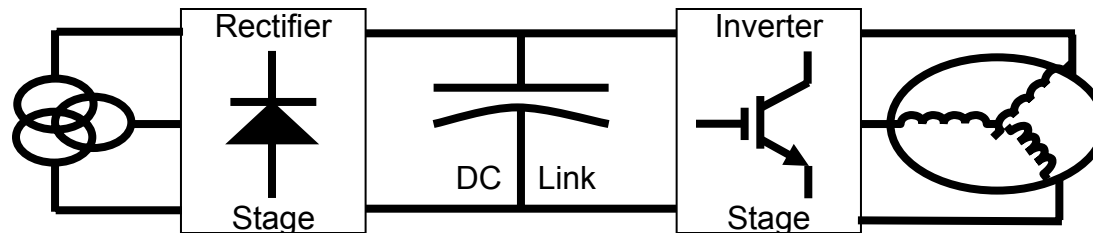


Stores DC Energy

- Energy stored as Voltage
- “Coke Can” style Capacitors
- Adverse forces from the System and Load is felt at the DC Link
- The Voltage is set by the Rectifier Stage, usually a fixed level
- Regenerative Power from load will increase the voltage on the Capacitors
 - Braking Resistors are used to keep the DC voltage from damaging the Capacitors

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AC Drives Inverter Stage



Converts DC Power to Variable AC Power

- Devices are IGBT
- Output waveform is PWM
 - Modulation Frequency about 1.7KHz
- Vector Controlled Firing of the IGBTs
- Encoder needed to monitor the Speed for Closed Loop Control

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Motor Speed

Speed = Frequency * 120 / Number of Poles

- 120 is a conversion factor – $60 * 2$
 - 60 is to convert the Frequency Time in Seconds to the Minutes used in RPM
 - 2 is for the Poles – All poles come in sets of two
- The Frequency of the AC power will affect the speed of the Rotor
- The Formula is for Synchronous Speed

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Motor Flux

Magnetic Lines of Flux

- Stator Flux is generated by the applied power
 - The Voltage and Current applied by the Drive
 - The Frequency of the applied power determines the direction of the Lines of Flux
- Stator Flux will cross the conductors of the Rotor Windings
- The Current induced in the Rotor creates Lines of Flux which oppose the Stator Lines of Flux
- The opposition of the Lines of Flux cause the Rotor to turn

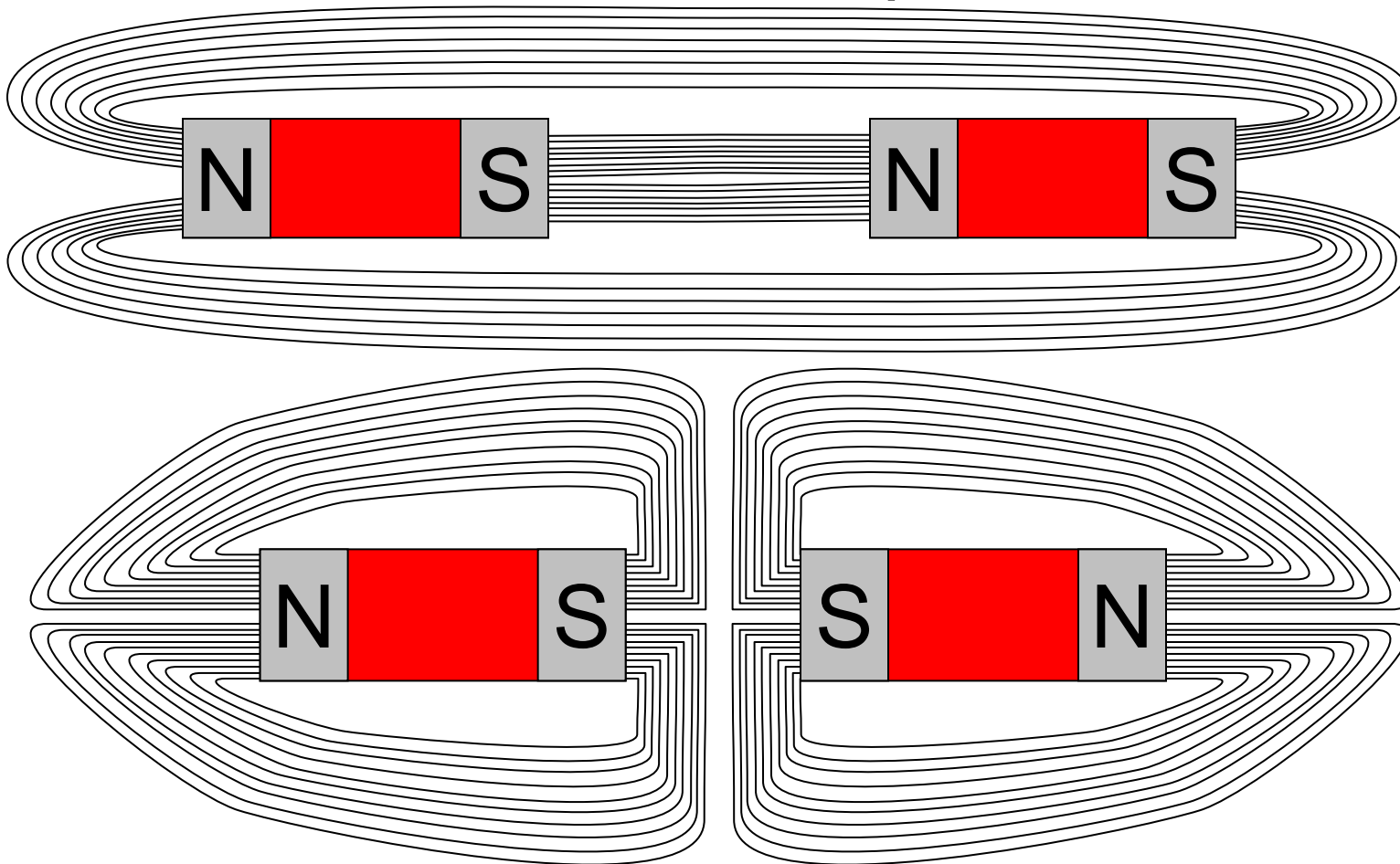
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Rotor Flux

- The Rotor is initially stationary
 - The Alternating Current cause the relative motion
 - This Changing directions is what causes current to be developed in the Rotor
- Rotor Windings are shorted together at the ends
 - The End Rings are usually where the windings get shorted
 - The shorted windings mean little voltage but High Current levels
 - The more current flowing the greater amount of Flux generated
- The Lines of Flux applied opposing each other means greater force available. This is equal to Rotational Torque

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Flux = Torque



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Lenz's Law

- An Induced Electromotive Force Generates a current that induces a counter Electromagnetic Field that opposes magnetic field generating it.
 - The Induced Electromotive Force is that which is applied by the AC Drive
 - The current flowing in the rotor will create a second magnetic field inside the motor
 - These two fields oppose each other
- Heinrich Lenz – Law developed in 1834

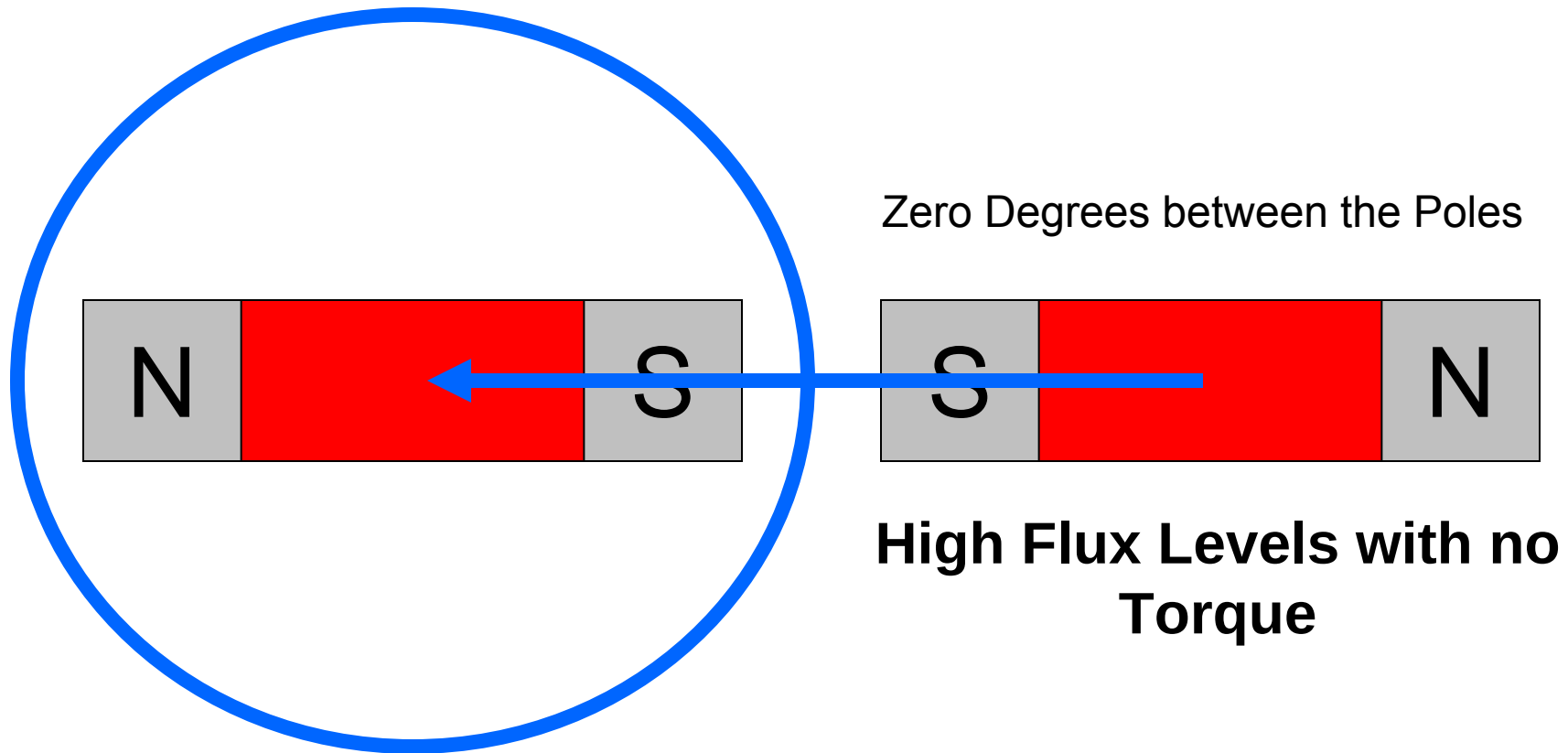
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Flux Line Properties

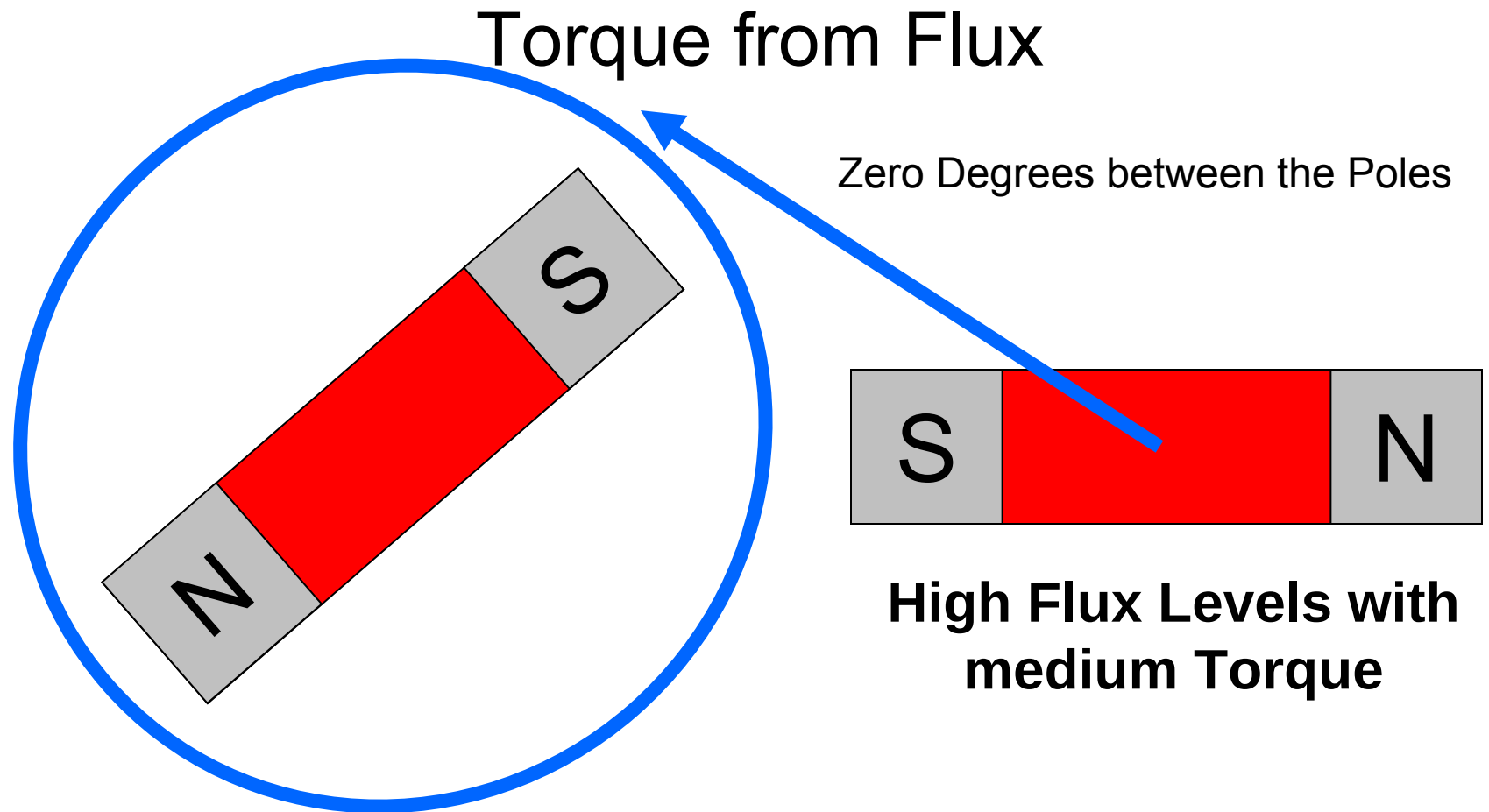
- Like Lines repel each other, Opposites Attract
- Lines Cannot cross
- Have Polarity or Direction
- Elastic – Will extend or retract to avoid similar polarities or connect to like polarities
- The Further out the weaker the field

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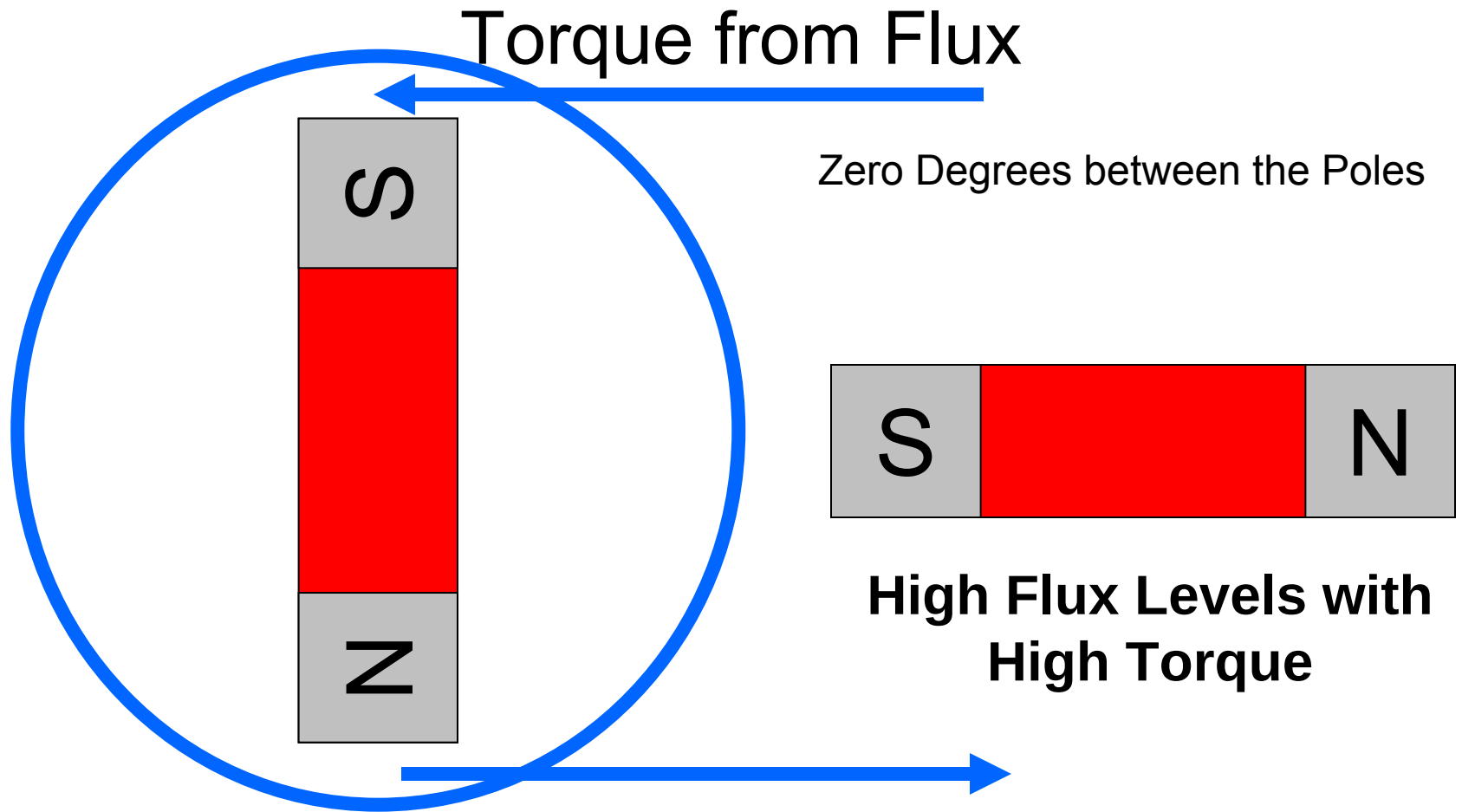
Torque from Flux



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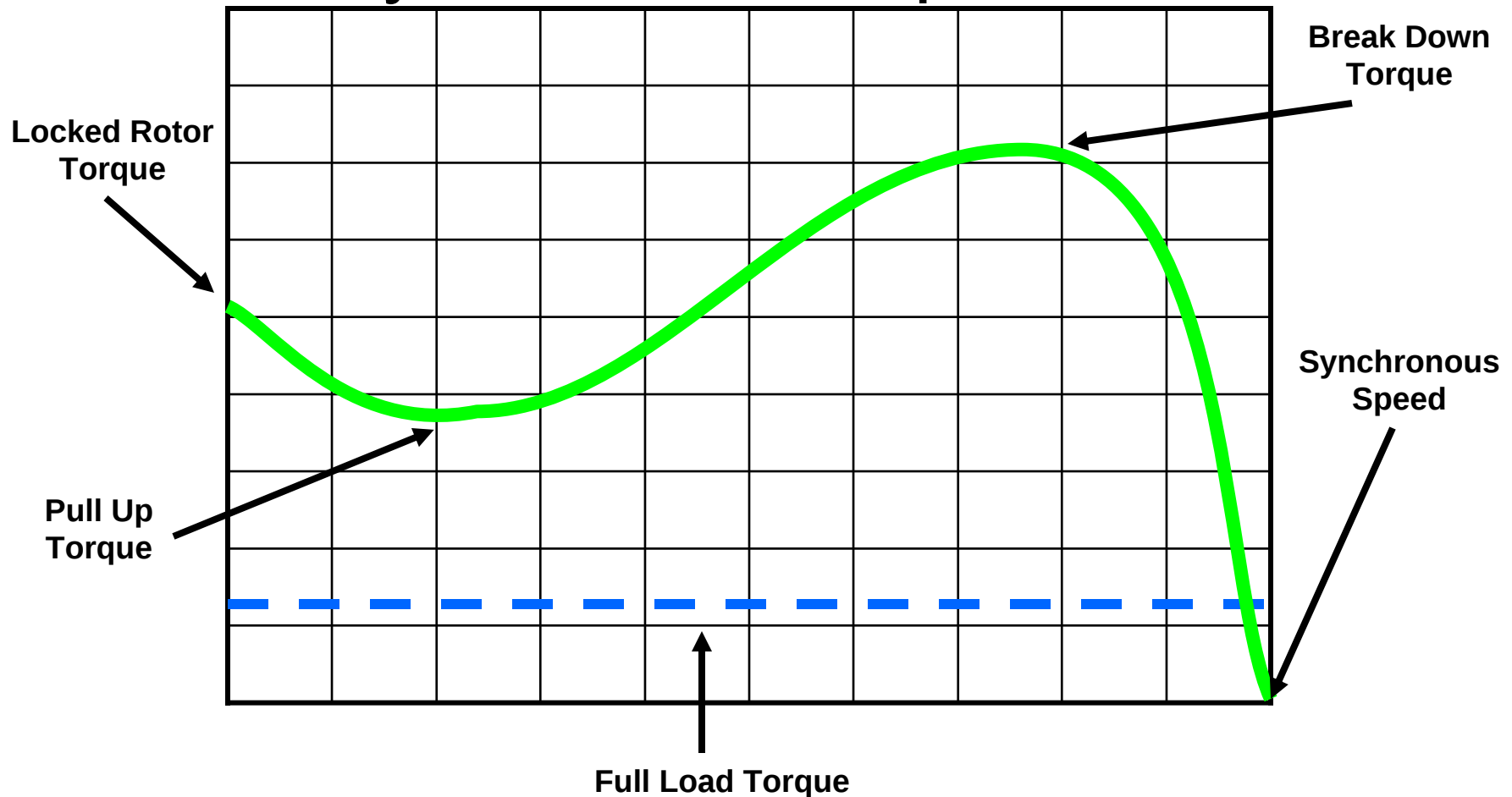
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Synchronous Speed

- Rotor Synchronous Speed
- Rotor Flux Lines “Line Up” with Stator Flux Lines
- No Torque is produced
- Rotor will not turn, preventing flux from being produced in the Rotor
- End Result the Rotor Slips
- This is called Synchronous Slip Speed

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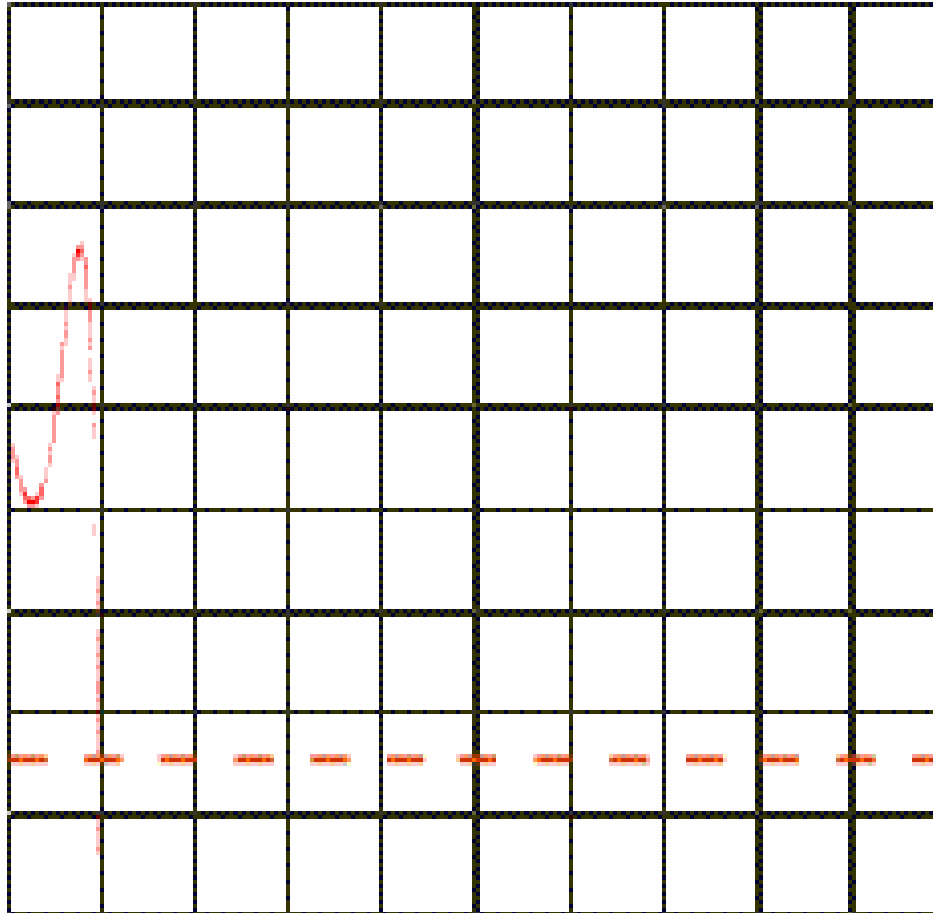
Synchronous Slip Curve



NOTE - Curve represents Stator Field at 60Hz

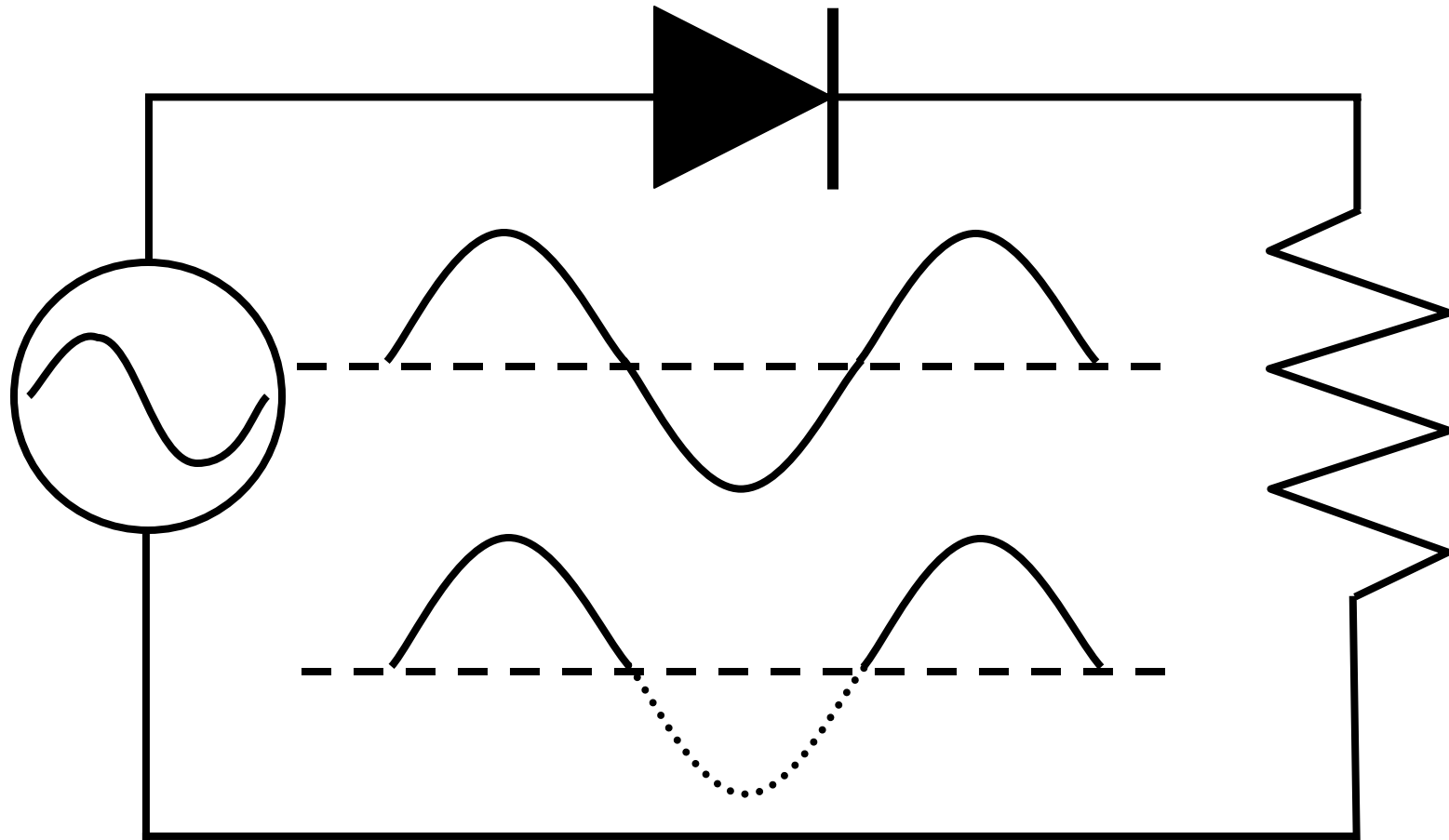
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Synchronous Slip Curve



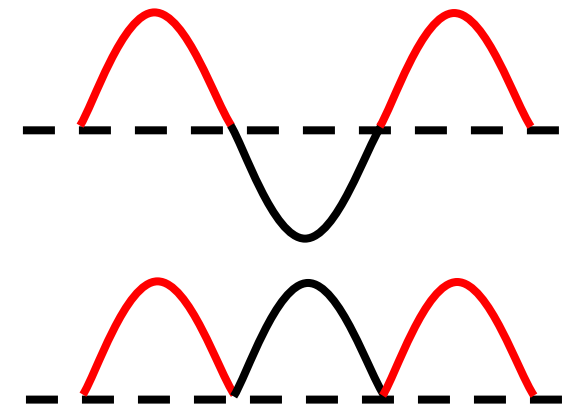
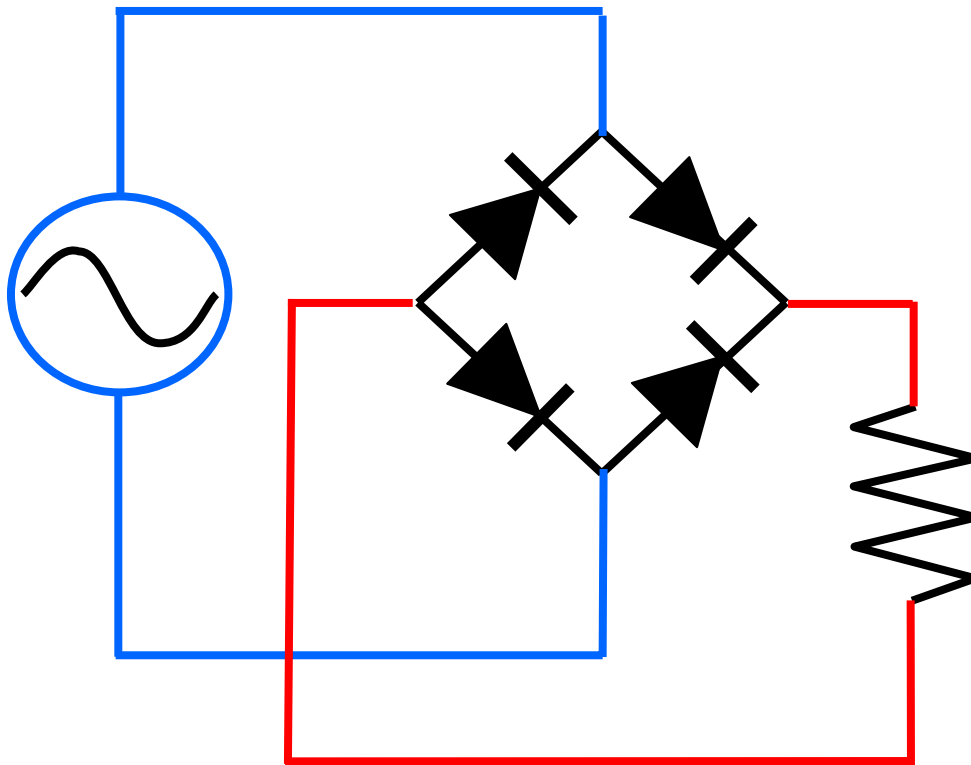
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Half Wave Diode Rectifier



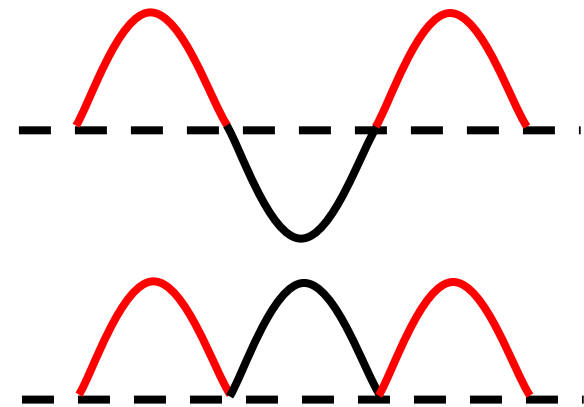
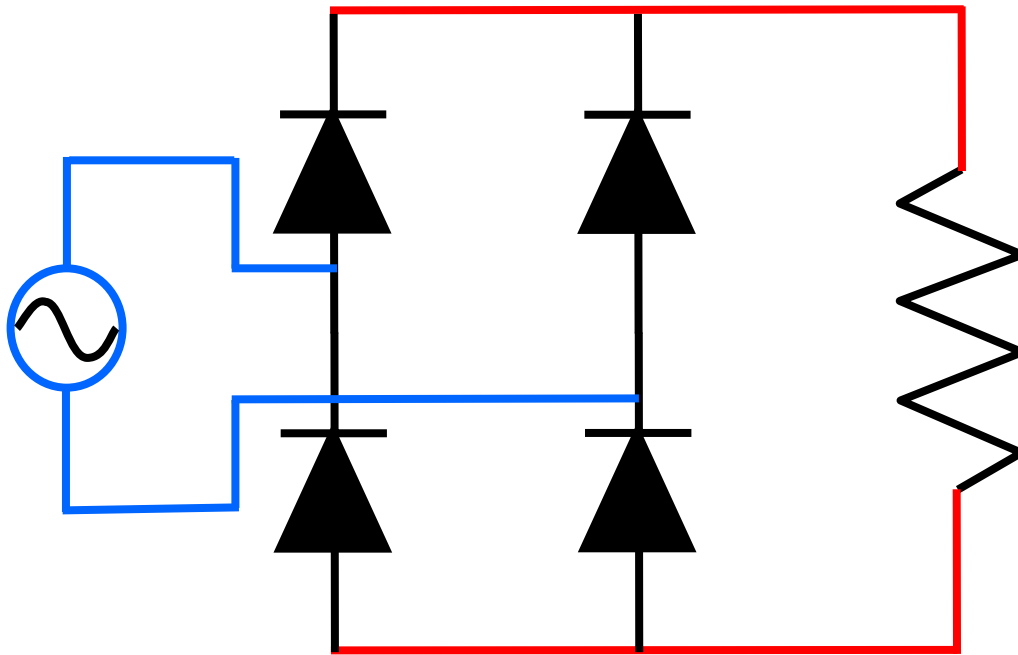
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Full Wave Diode Rectifier



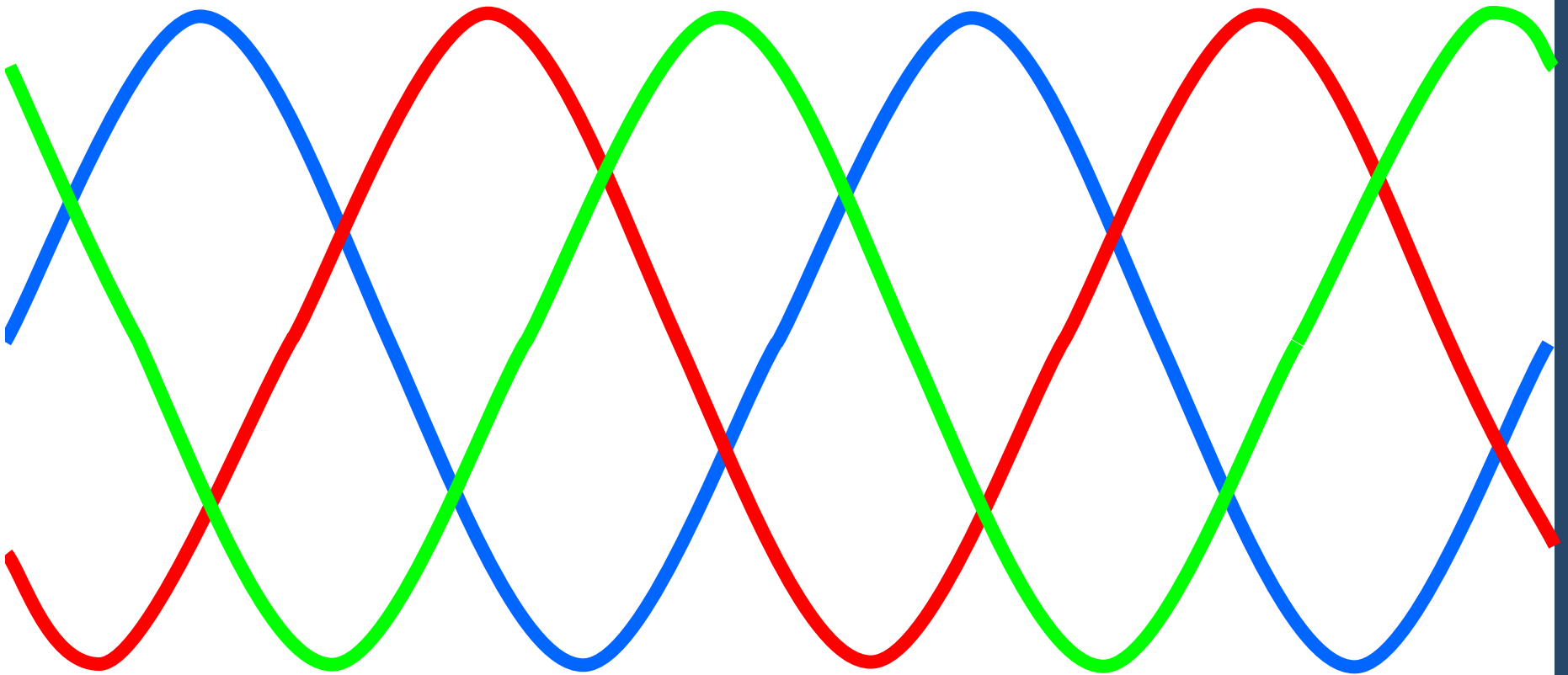
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Full Wave Diode Rectifier – H Configuration



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Three Phase AC Power



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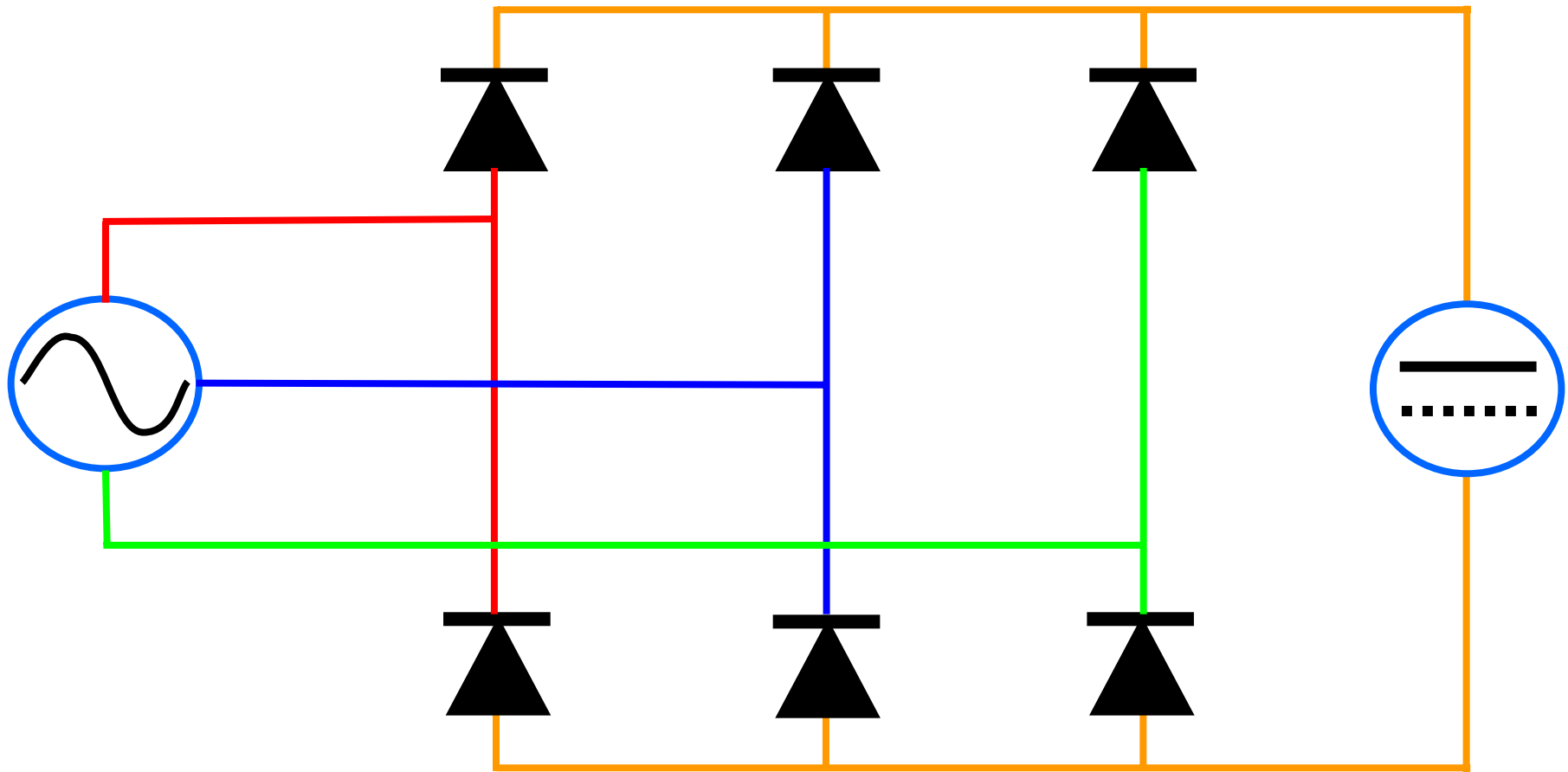
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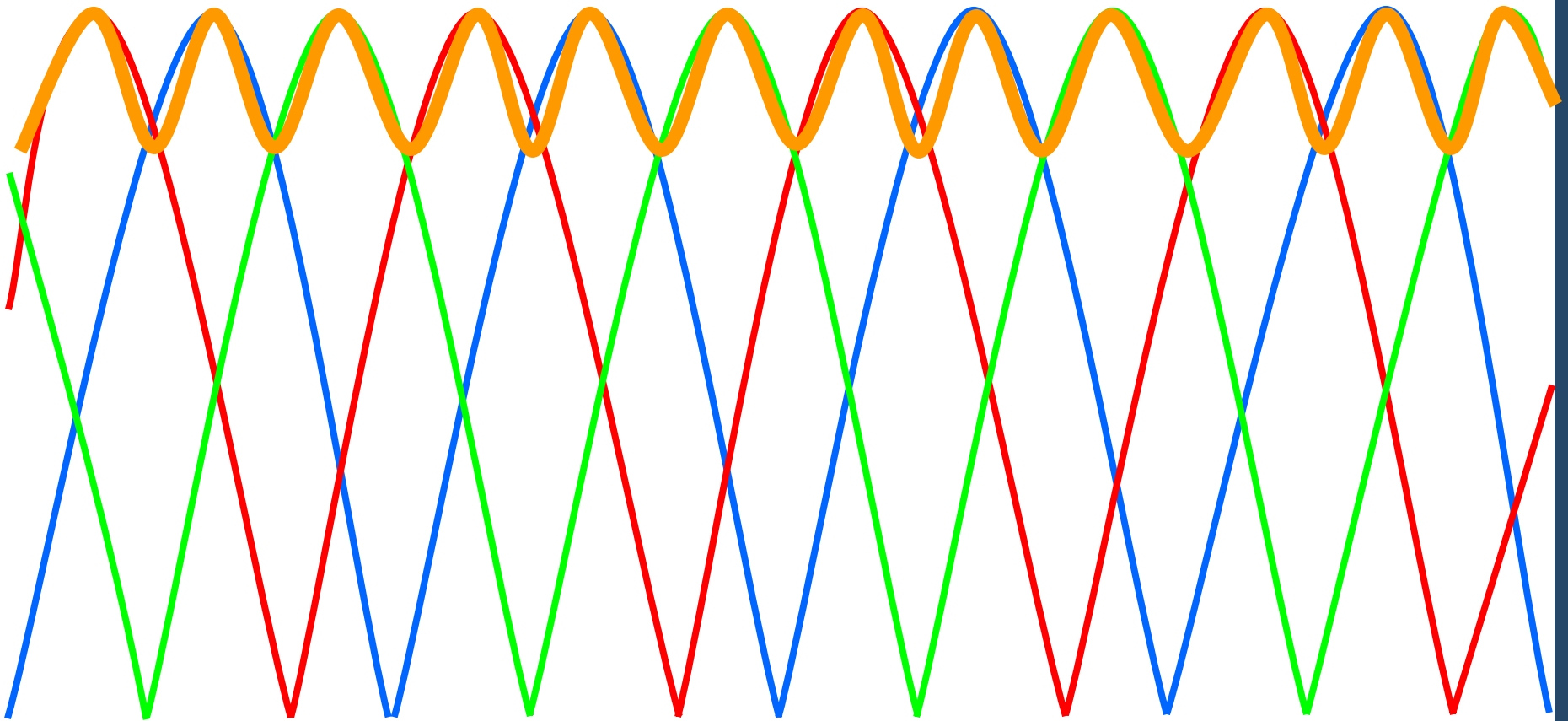
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Three Phase Full Wave Diode Rectifier



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Three Phase AC Power



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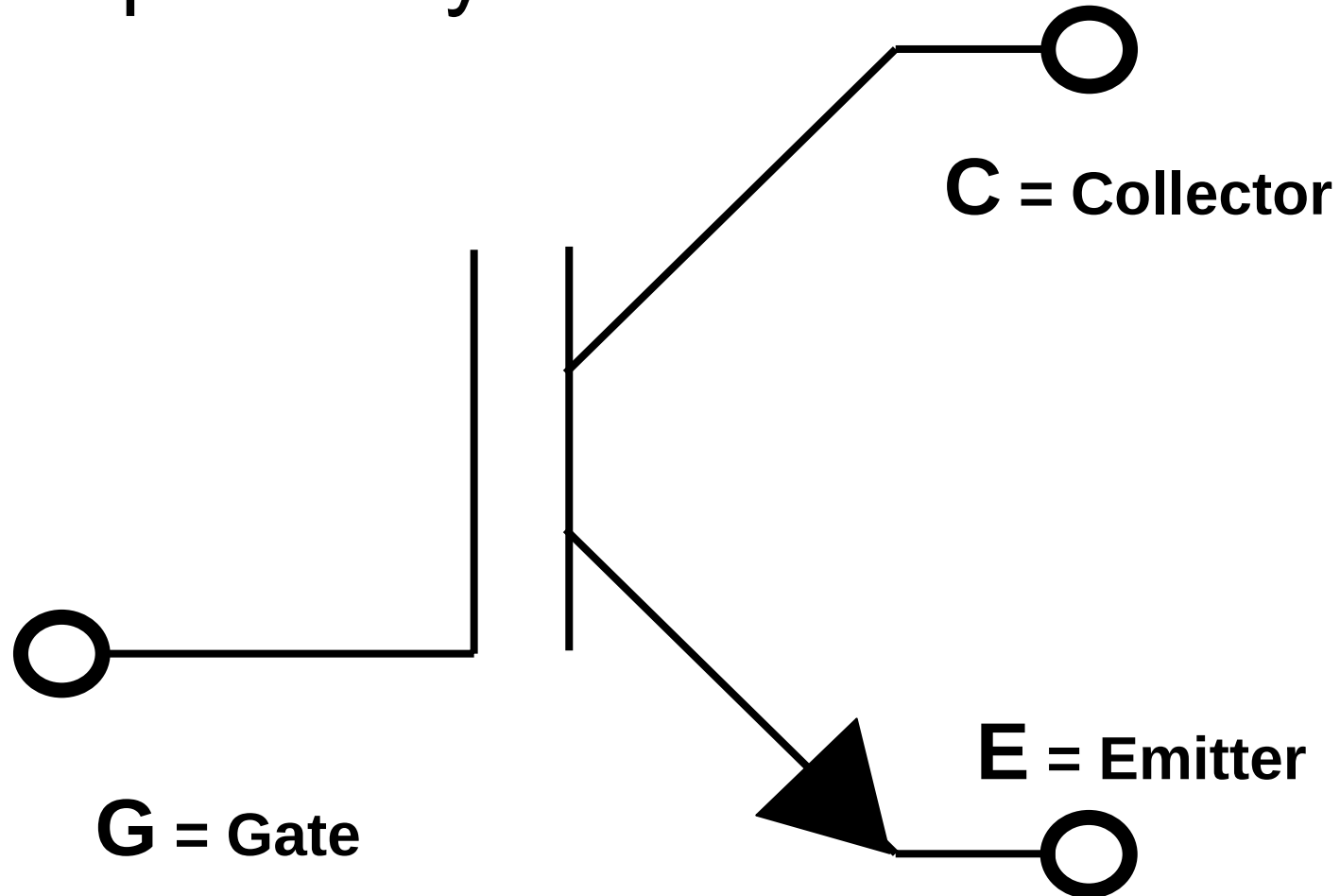
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IGBT

- Insulated Gate Bipolar Transistor
- Switch
 - Not an Amplifier
 - In the Linear Range, the device goes boom
Turn On and Turn Off
- Fast
 - Device will turn on in less than .1 Microseconds
3 – 5 Kilo-Volts per microsecond with a Load
10 Kilo-Volts per microsecond with no Load
 - Device will turn off on less than .5 Microseconds

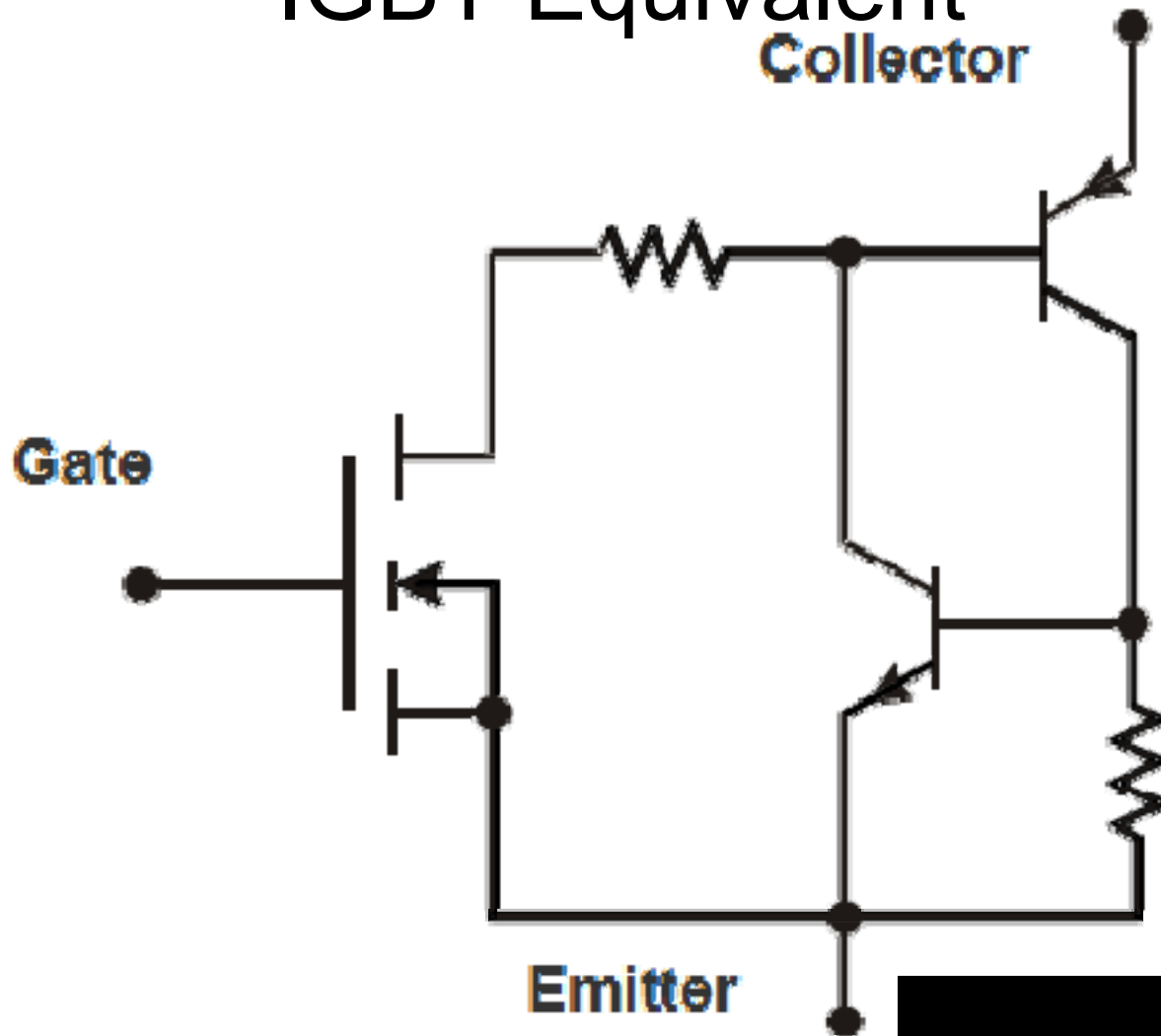
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Simplified Symbol for an IGBT



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IGBT Equivalent



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EUPEC IGBT

- Three IGBT blocks per package
- Six IGBT devices per block
- Six flyback diodes per block (Parallel to IGBT)
- Multiple Sensors
 - DC Voltage
 - AC Current
 - Temperature Sensors
 - Firing Status
 - IGBT Faults

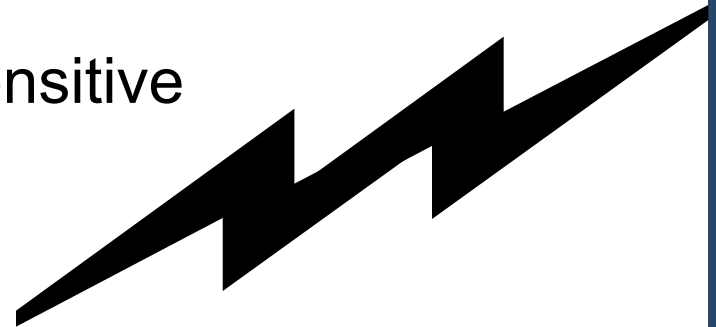
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IGBT Caution

No Touchy Touchy !!!!!!!

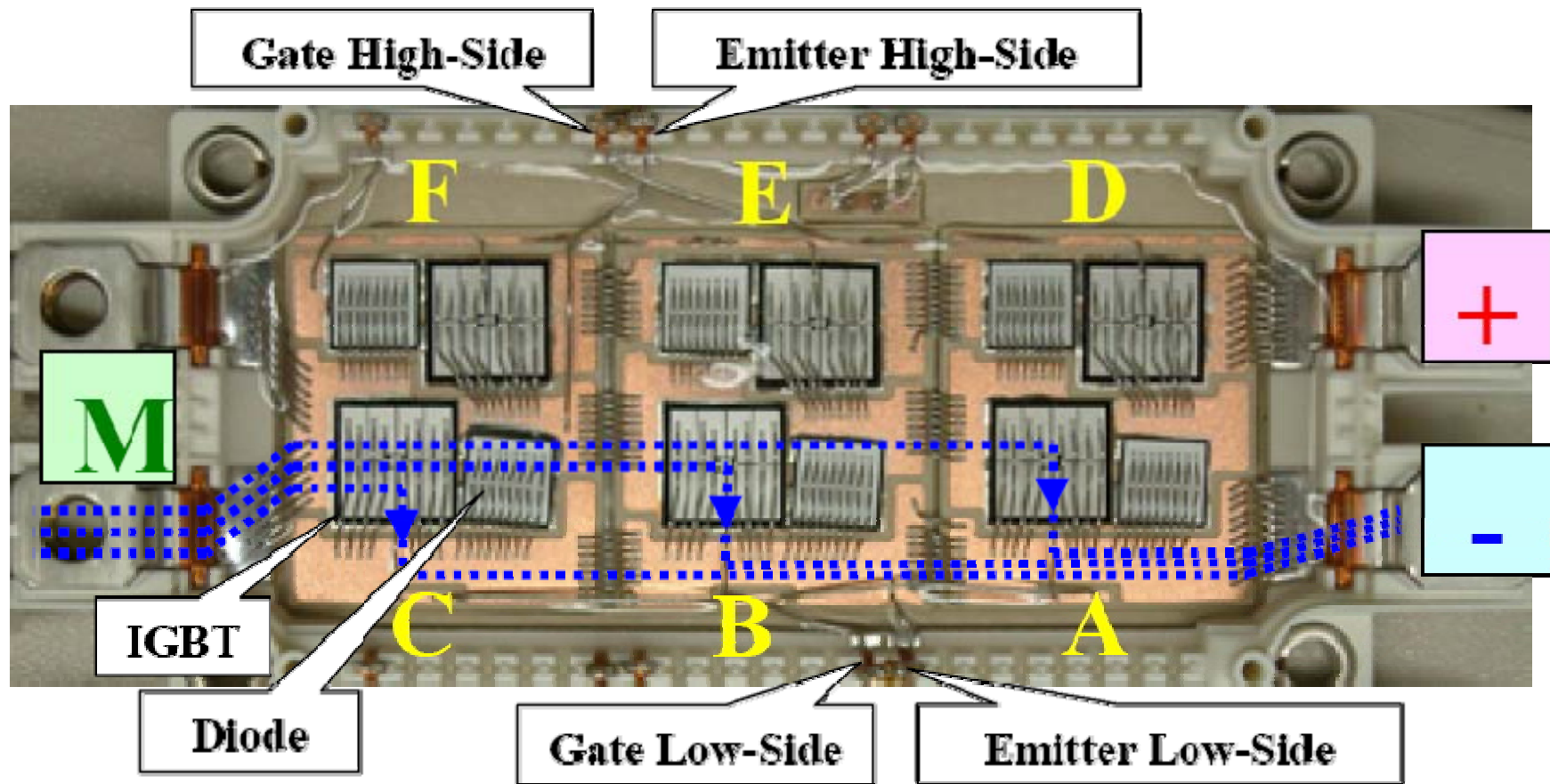


Extremely Static Sensitive



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IGBT Inside



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The Inverter Bridge



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ABB AC Drive Inverter



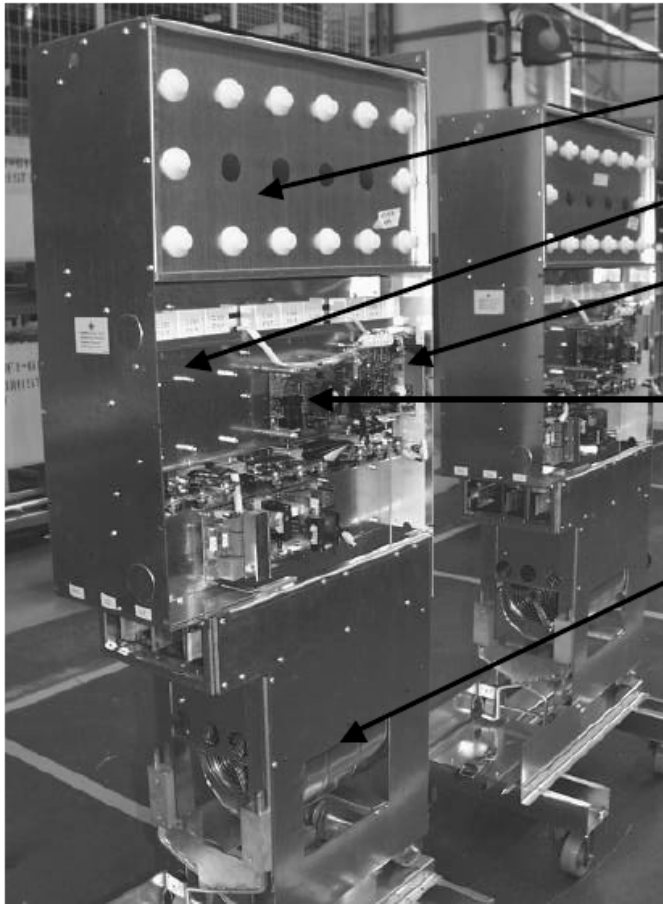
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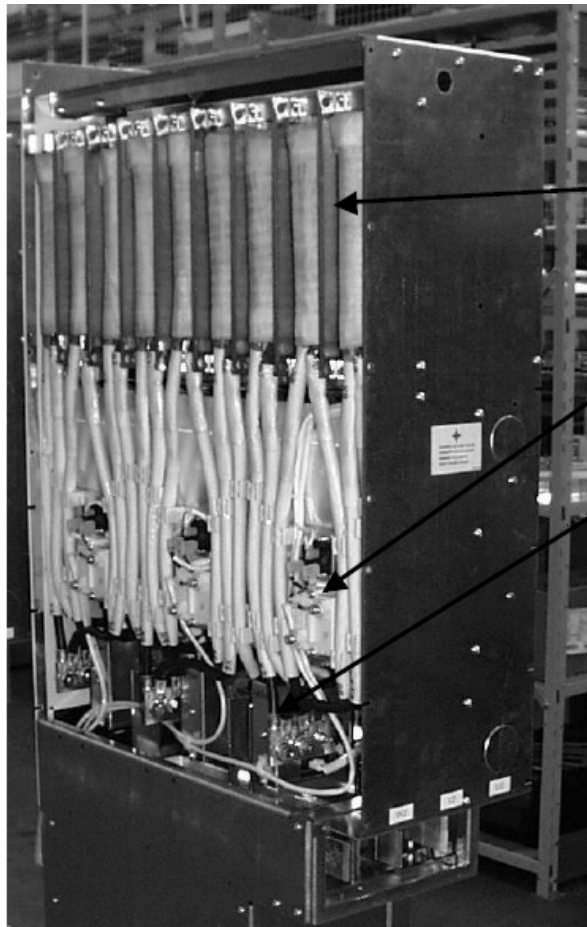
ABB Inverter Bridge



- Capacitors
- IGBT:s & Gate drivers
- Main Circuit Board AINT-01C / AINT-12C
- APOW-01C power supply
- Fan in the bottom

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ABB Inverter Bridge



- Output reactors
- Discharging resistors
- Current transducers

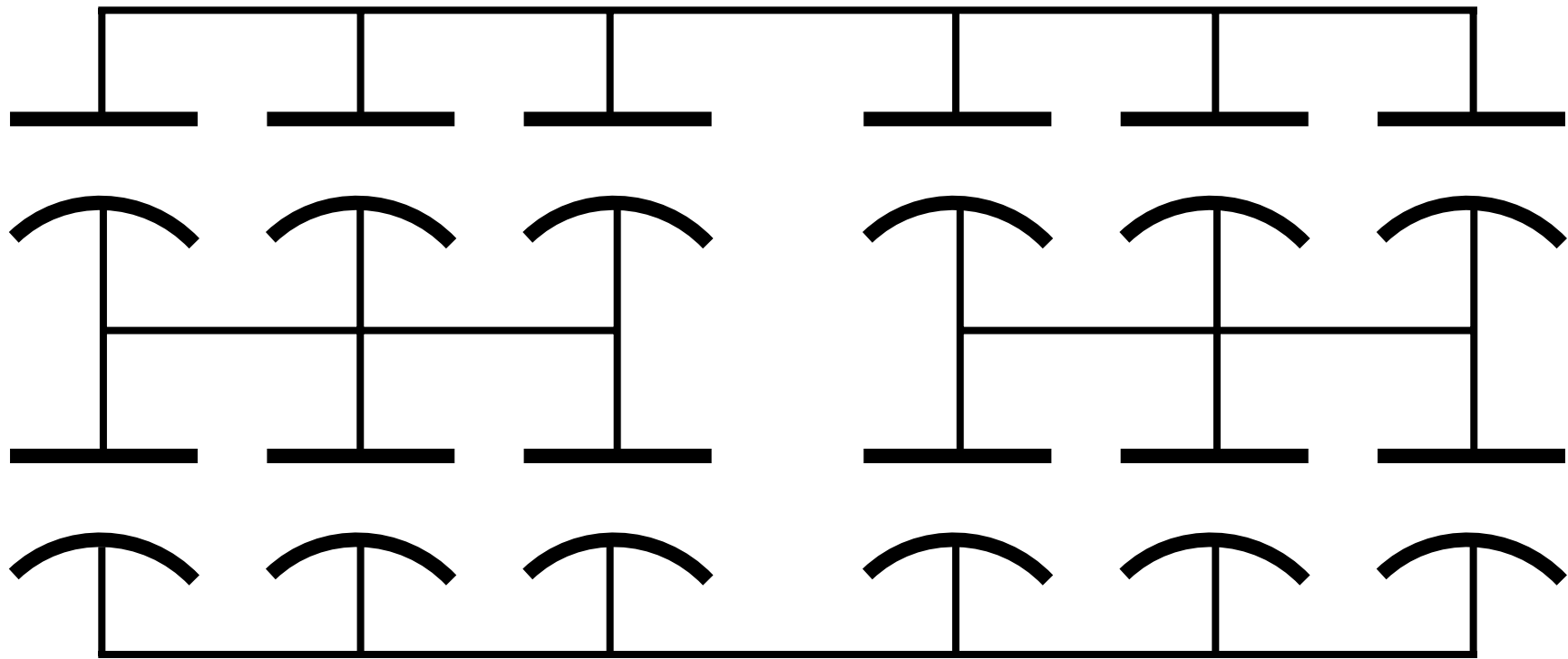
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NOV Inverter Cubicle



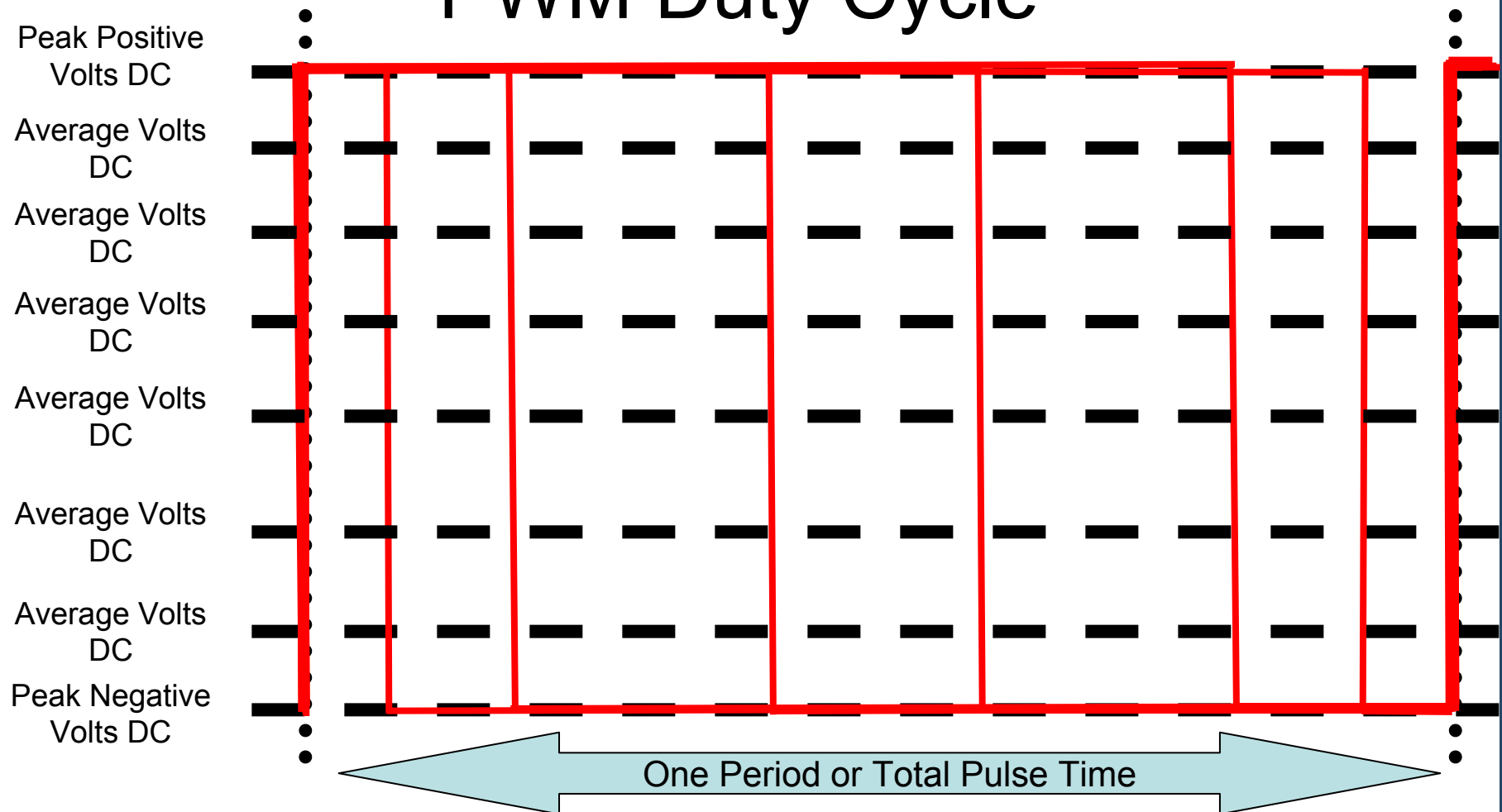
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ABB DC Link (Capacitive)



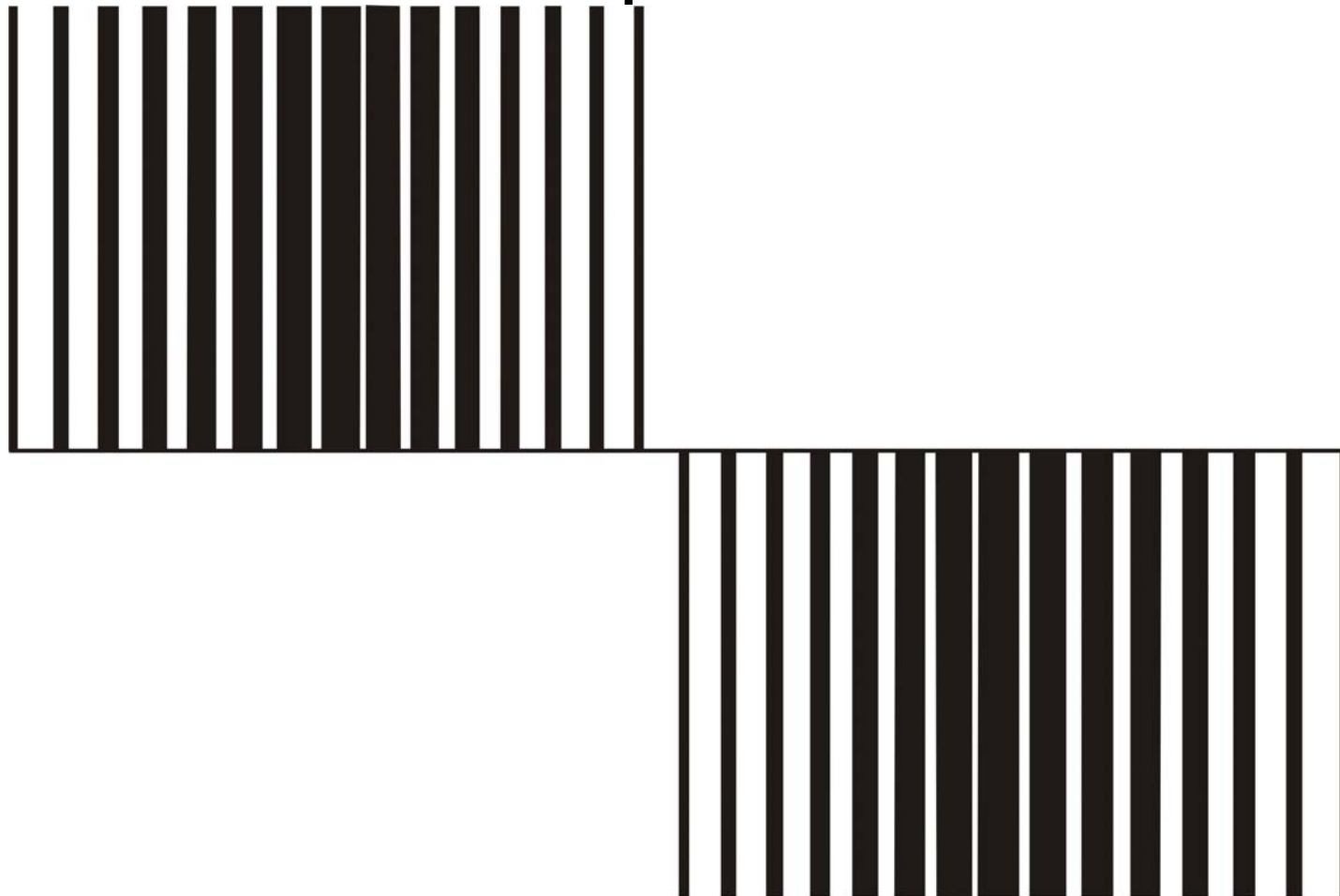
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PWM Duty Cycle



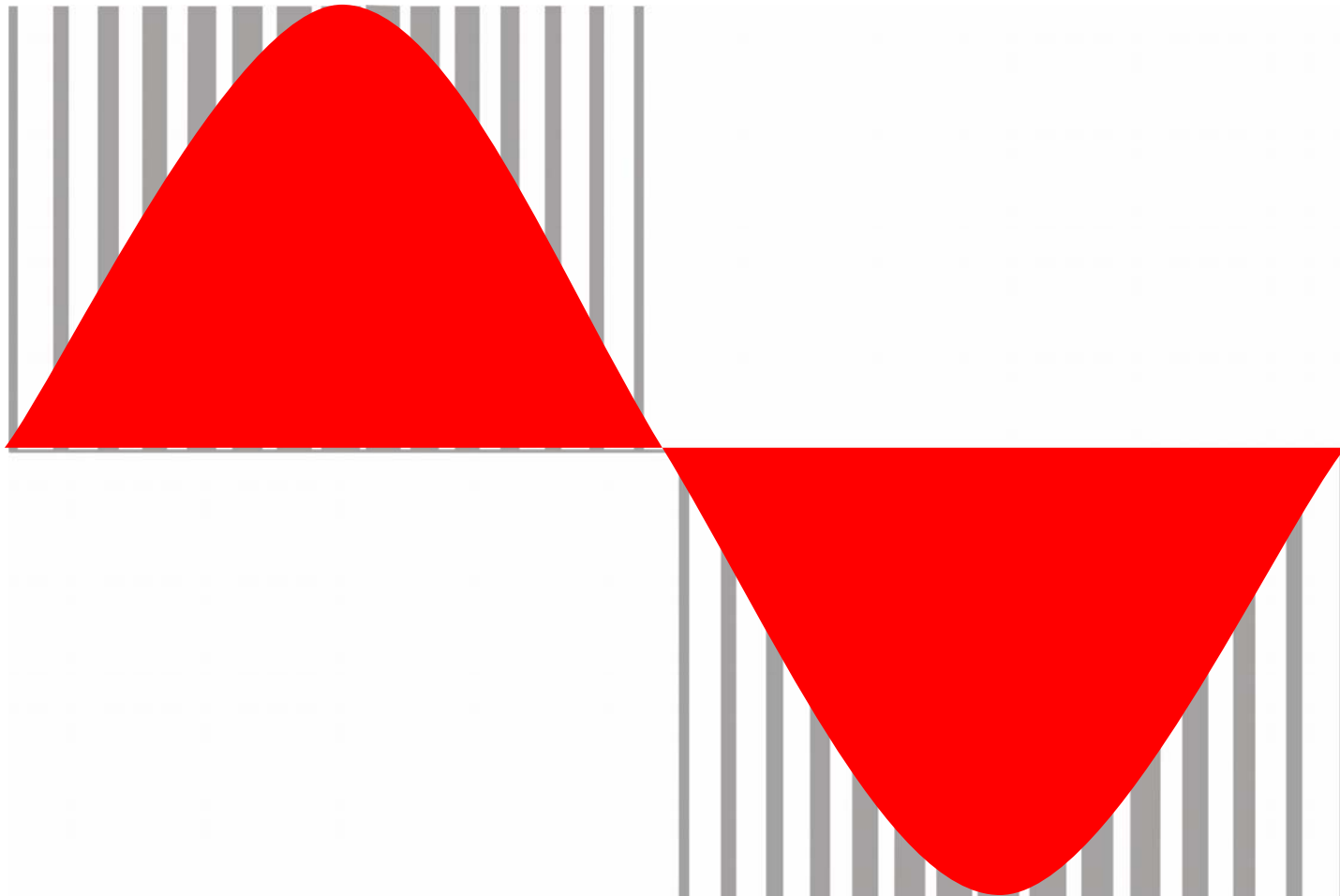
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PWM AC Output Waveform



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What the Motor Sees



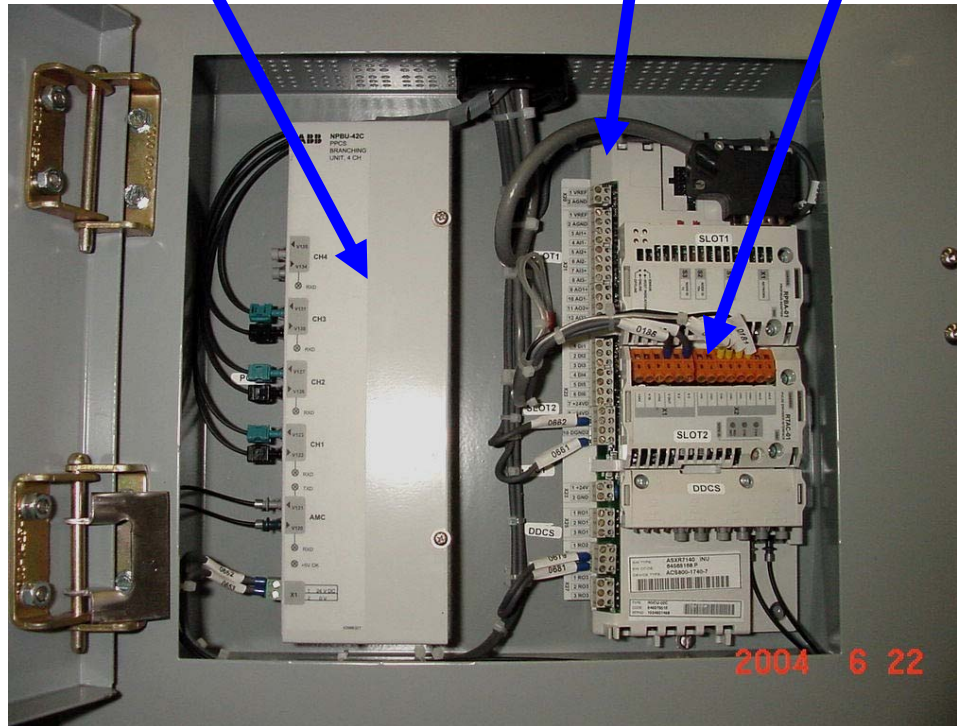
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Bridge Controller

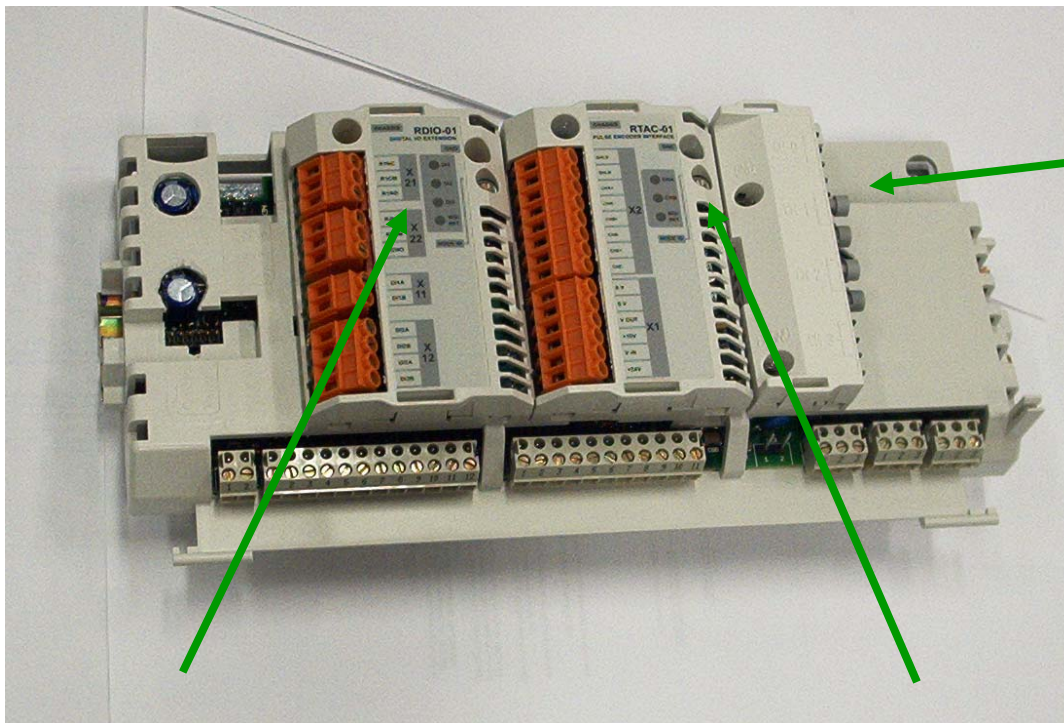
Fiber Optic
Branching Unit

RMIO Board
with Auxiliary
I/O Boards



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RDCU Layout



Optic links (DDCS) (SLOT1)

RDCO-x adapter with 4 channels. 3 versions, -01, -02, -03, normally supplied with version -01

- **CH0** - Fieldbus modules
All ACS600 Nxxx modules
- **CH1** - add motherboard AIMA, and use RDIO, RAIO, RTAC OR* - use NDIO, NAIO, NTAC
- **CH2** - Master follower, NTAC
- **CH3** - PC connection for DriveAP and Drive Windows.

I/O extentions

(either for SLOT1 or SLOT2)

- **RTAC-01**
- **RDIO-01**
- **RAIO-01**

Field Bus Adapters

(SLOT1)

- **DeviceNet**
- **Lonwork**
- **Interbus – s**
- **Profibus DP**
- **Can-Open**
- **Modbus**

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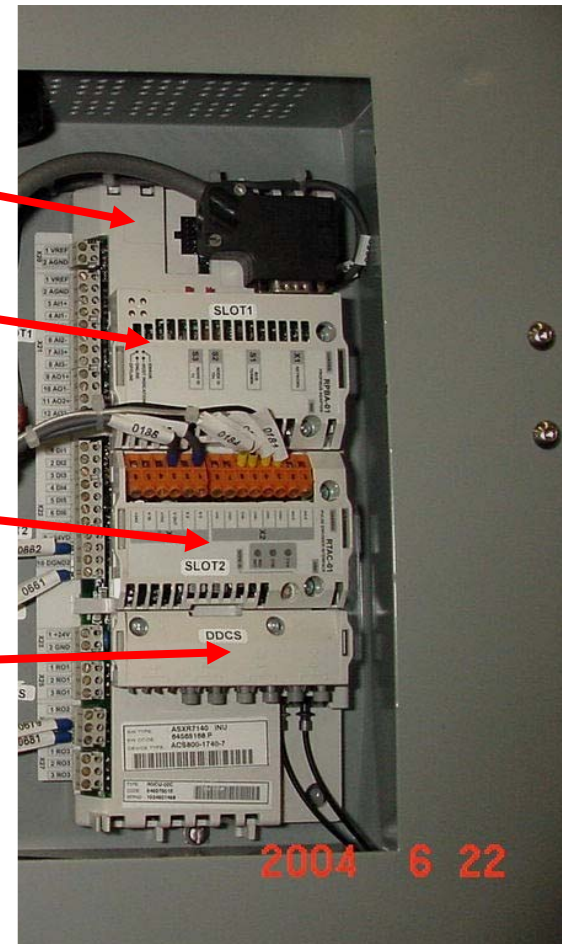
RDCU Bridge Controller

RMIO Board

Profibus DP
PLC Interface
Board

Digital I/O or
Analog I/O
Option Board

Fiber Optic
Bridge Firing
Board



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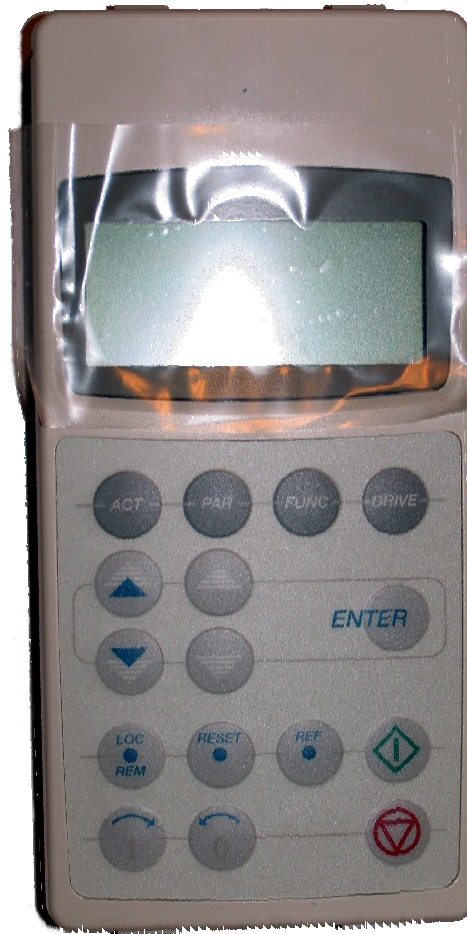
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RMIO Board



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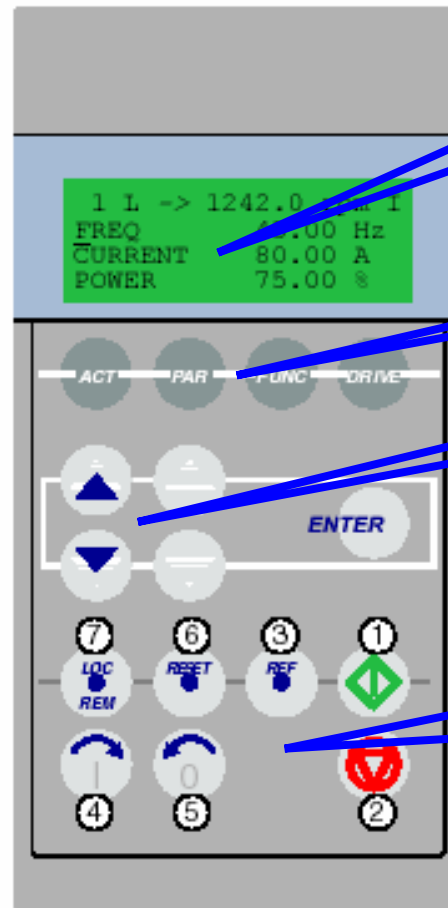
Keypad



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Keypad

No.	Use
1	Start
2	Stop
3	Activate reference setting
4	Forward direction of rotation
5	Reverse direction of rotation
6	Fault reset
7	Change between Local / Remote (external) control



Drive Display

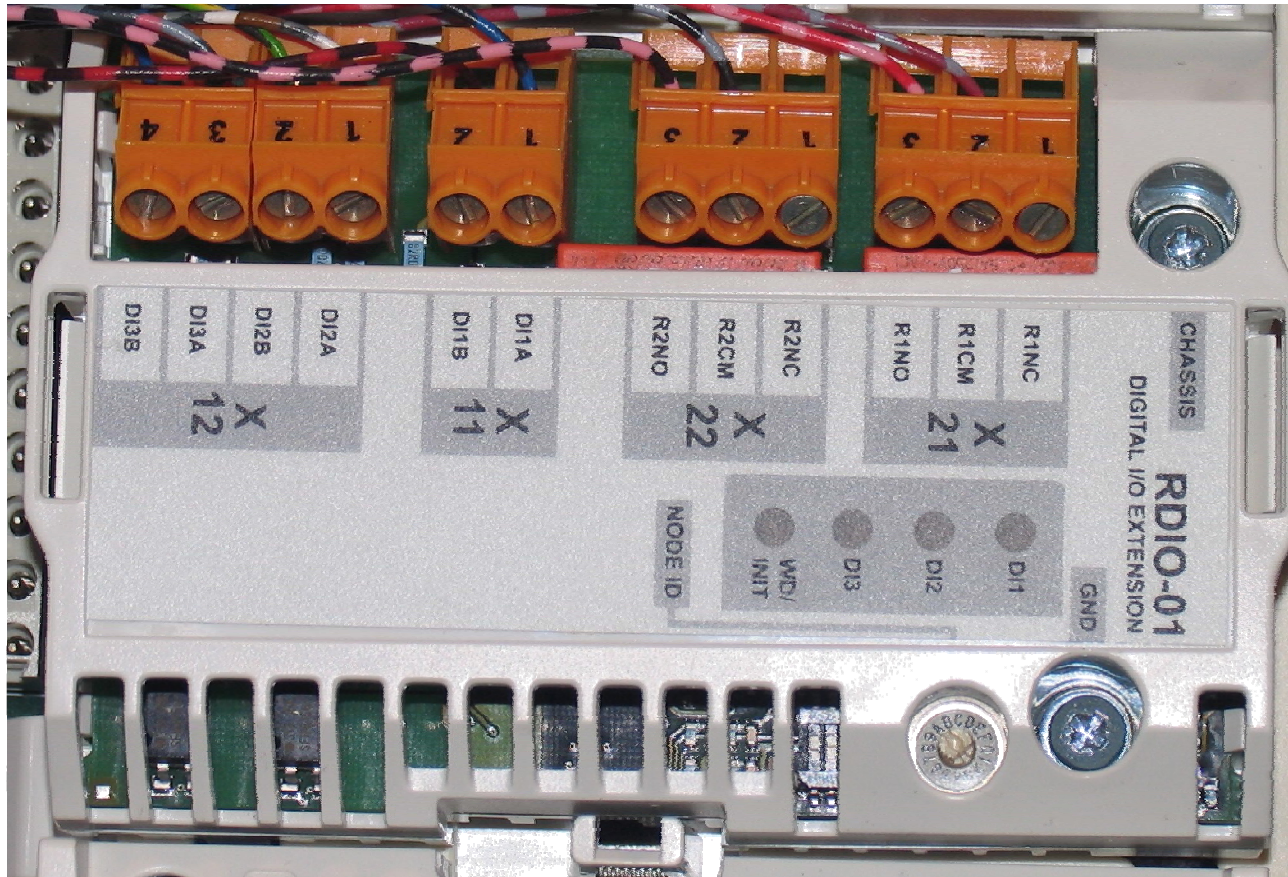
Access Buttons

Scroll Buttons

Command Buttons

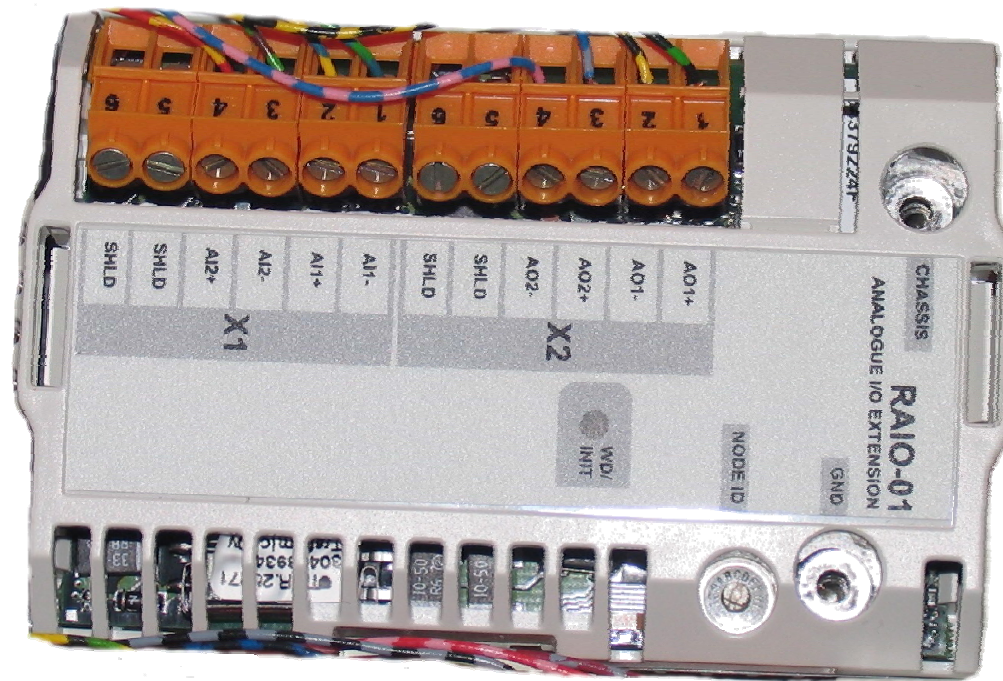
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Digital Input/Output Board



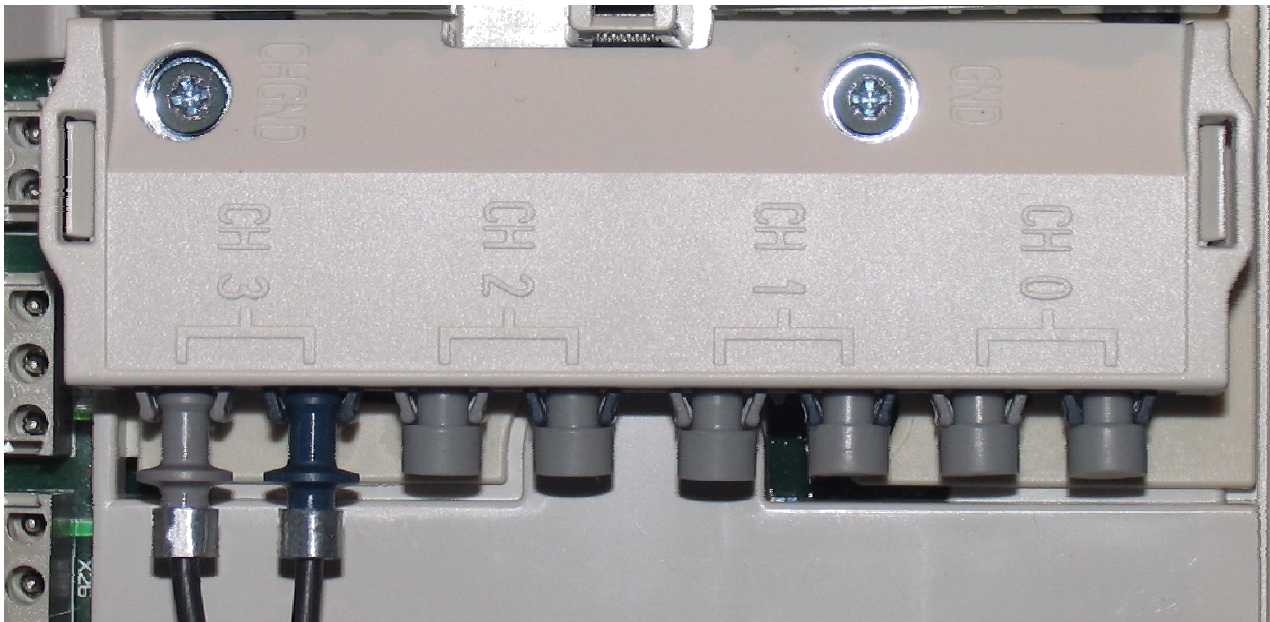
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Analog Input/Output Board



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Optical Link DDCS



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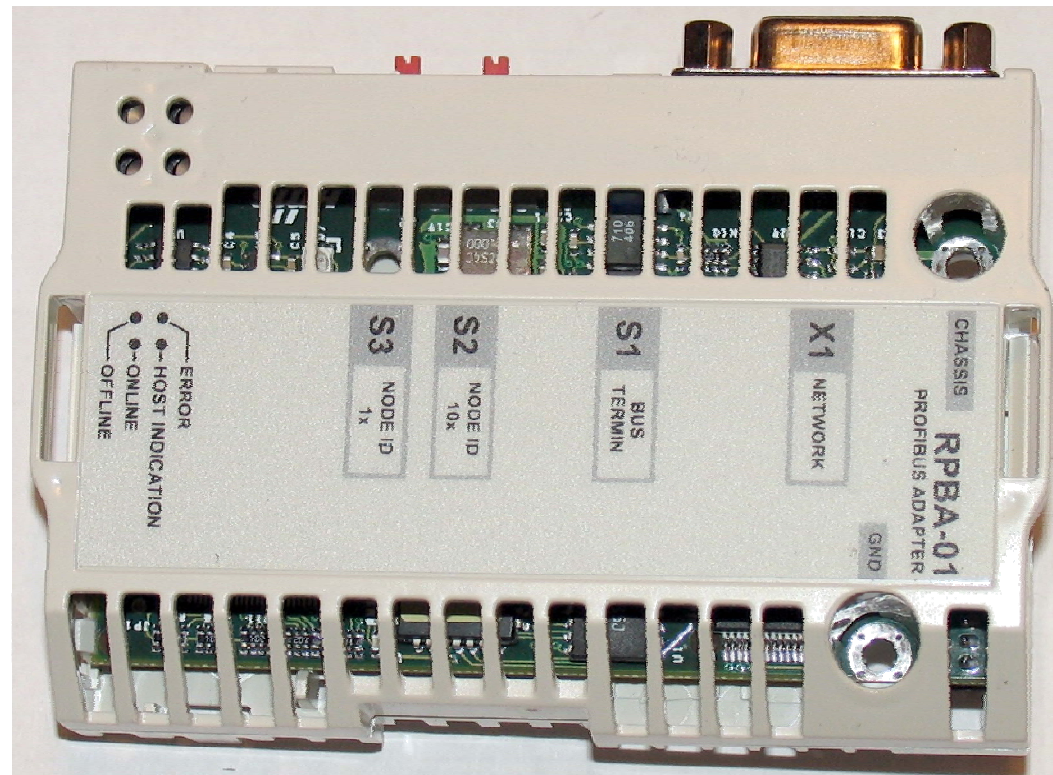
Optical Link DDCS

RDCO-x adapter with 4 channels. 3 versions, -01, -02, -03, normally supplied with version -01

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- **CH2** - Master follower, NTAC
- **CH3** - PC connection for DriveAP and Drive Windows.

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Communications Board – Profibus DP



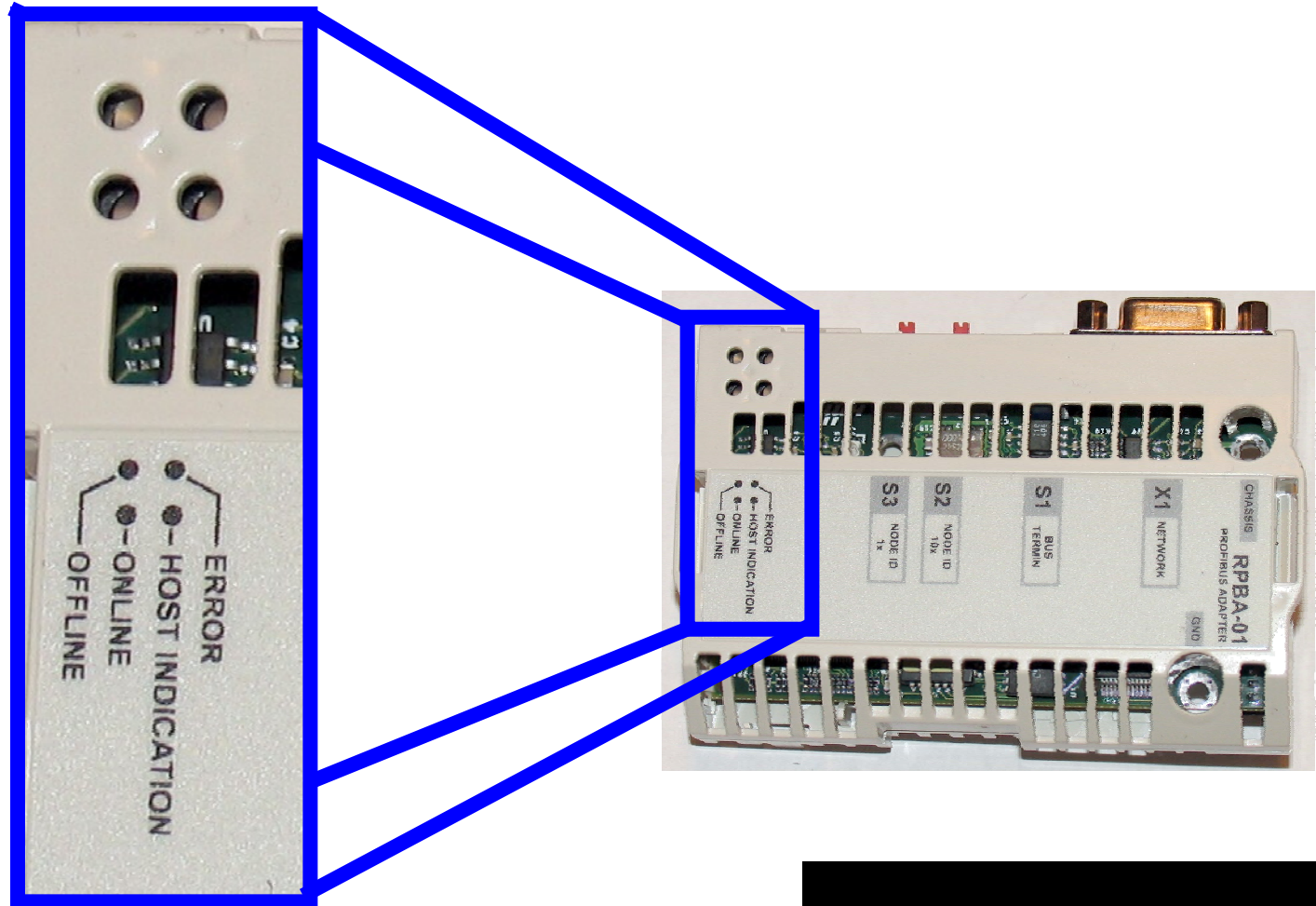
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Communications Board – Profibus DP

- Siemens Profibus DP Network
- Connects between the PLC CPU X2 Port and the RPBA - 01 Board
- Does not connect to slave drives or the Brake Chopper
- Termination Resistors are critical to the Network

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Communications Board – Status LEDs



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Communications Board – Status LEDs

■ Error LED (**RED**)

- On = Communications Error
- Off = Normal

■ Offline LED (**RED**)

- Off = The system is online with the Drive and is capable of communicating with the PLC, the Profibus DB network is detected
- On = The Board doesn't detect the network
 - The Profibus Network cable is broken
 - The CPU Key switch of the PLC is in the Stop Position
 - The Terminations switch is not set properly
 - The Node Address is not set properly

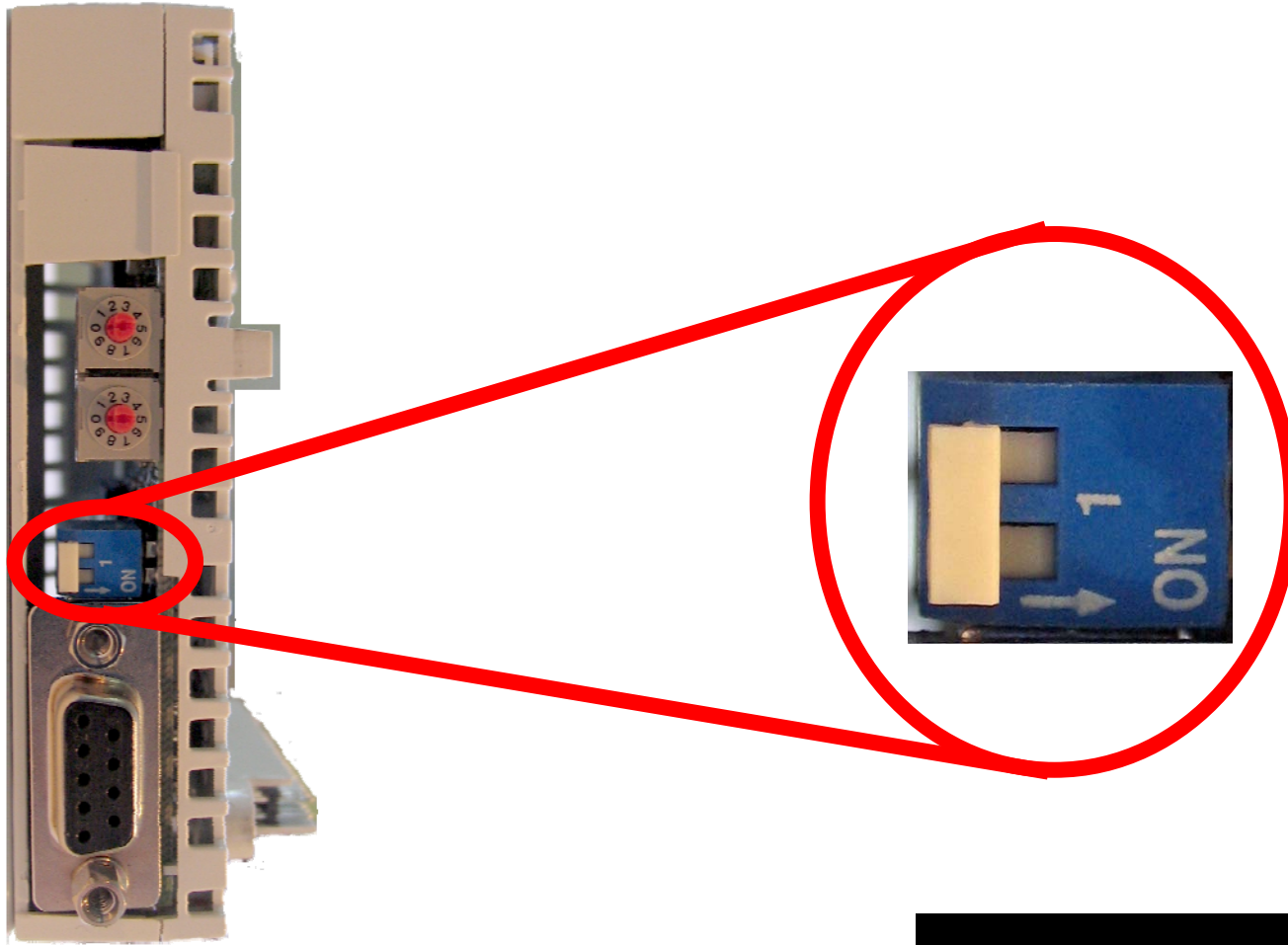
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Communications Board – Status LEDs

- **Fieldbus Status LED ((Green))**
 - Off = No External Communications
 - On = Fieldbus module Active
 - Blinking Fast (Once per second) = Active with good communications
 - Blinking Slow (Once every five seconds) = No communications with Profibus DP master (PLC CPU)

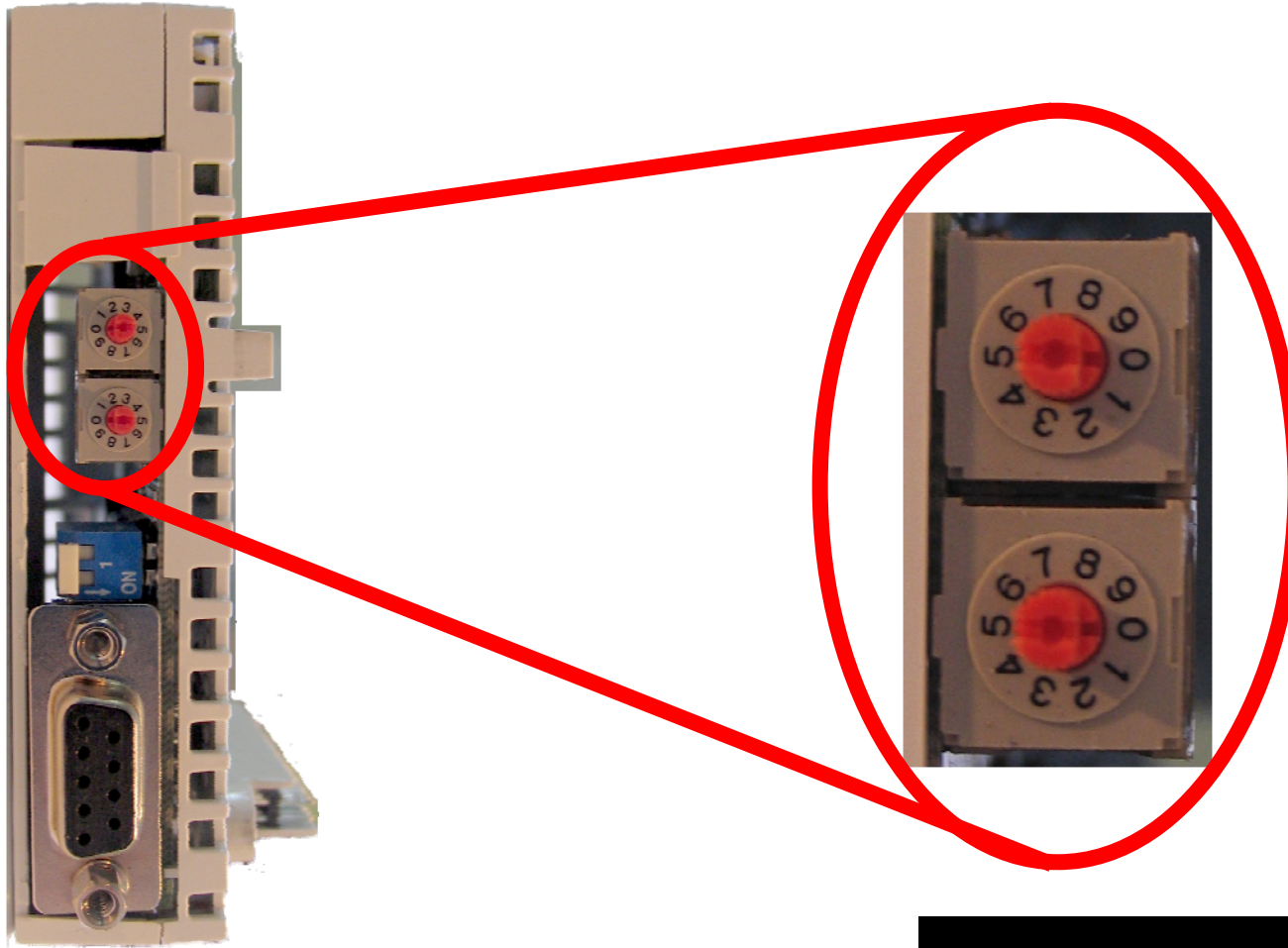
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Communications Board – Termination



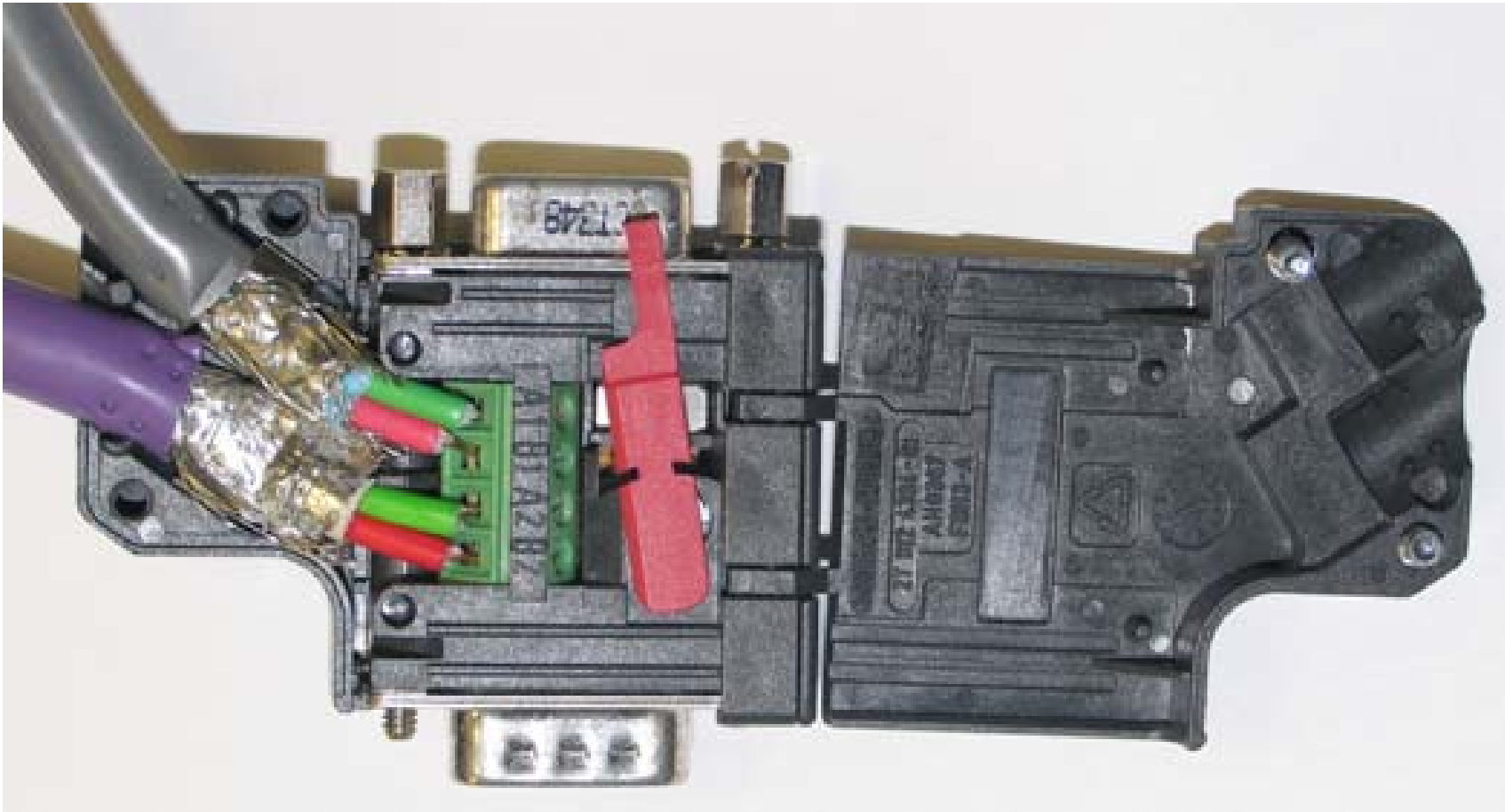
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Communications Board – Node Address



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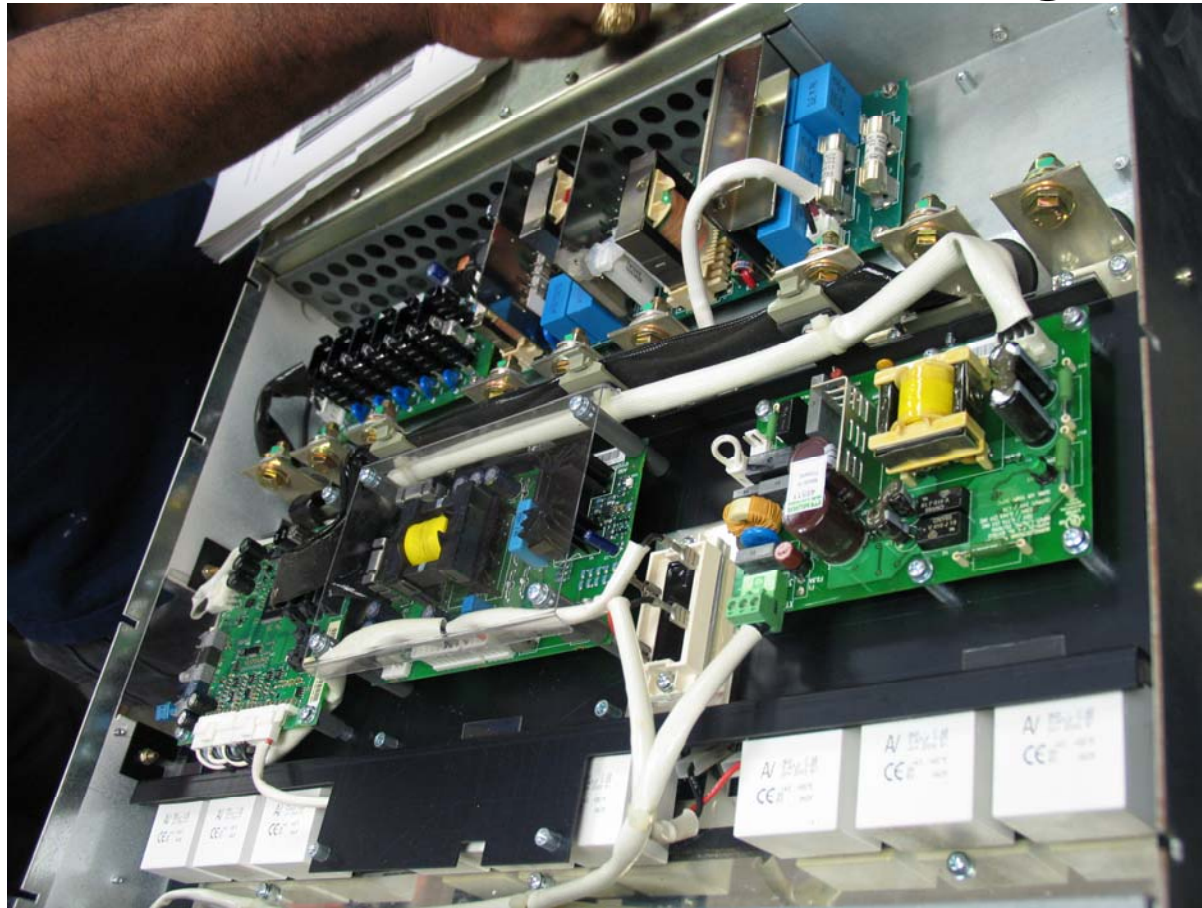
Communications Board – Cabling



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Inside the Inverter Bridge



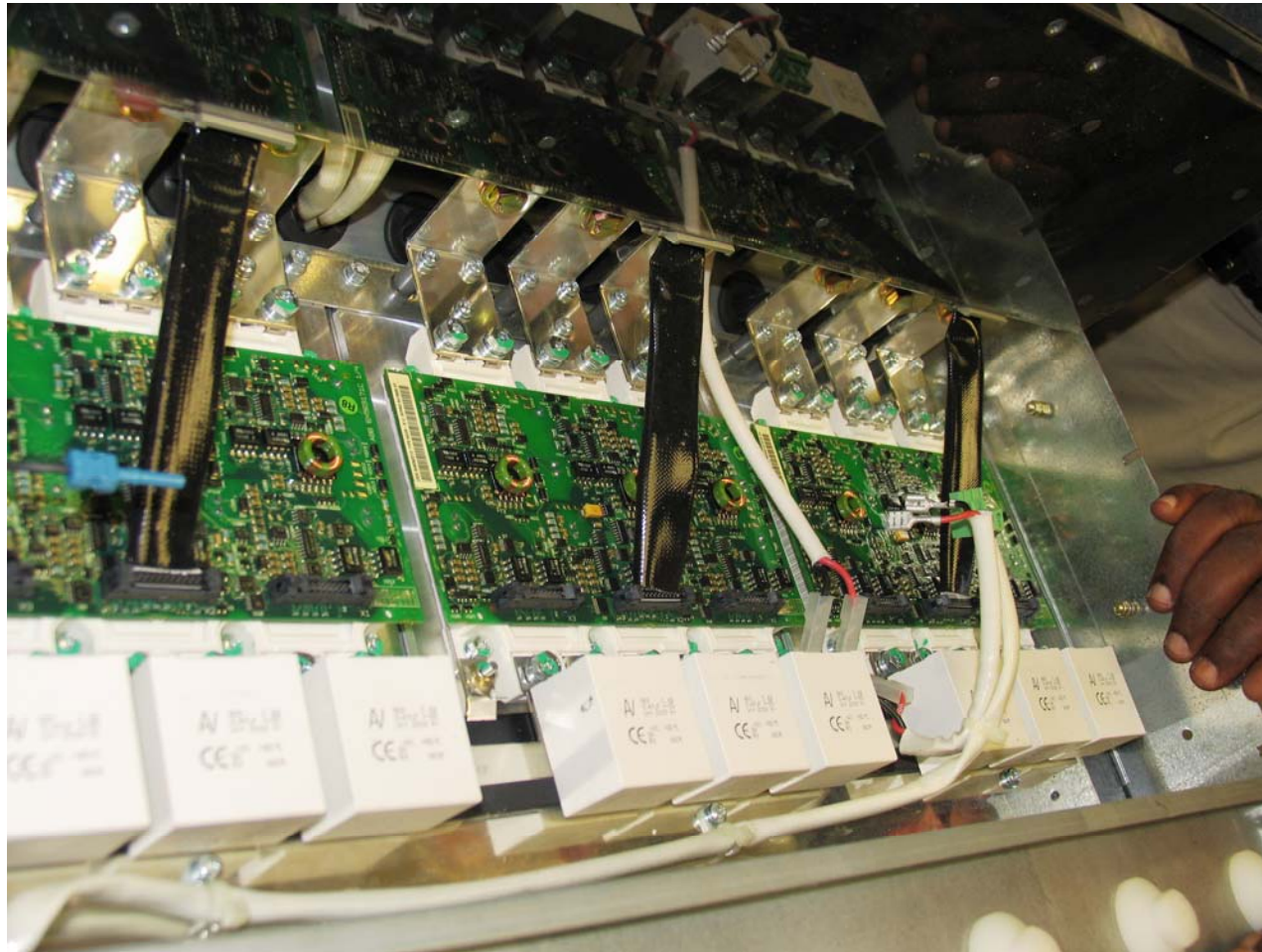
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Gate Drive Board



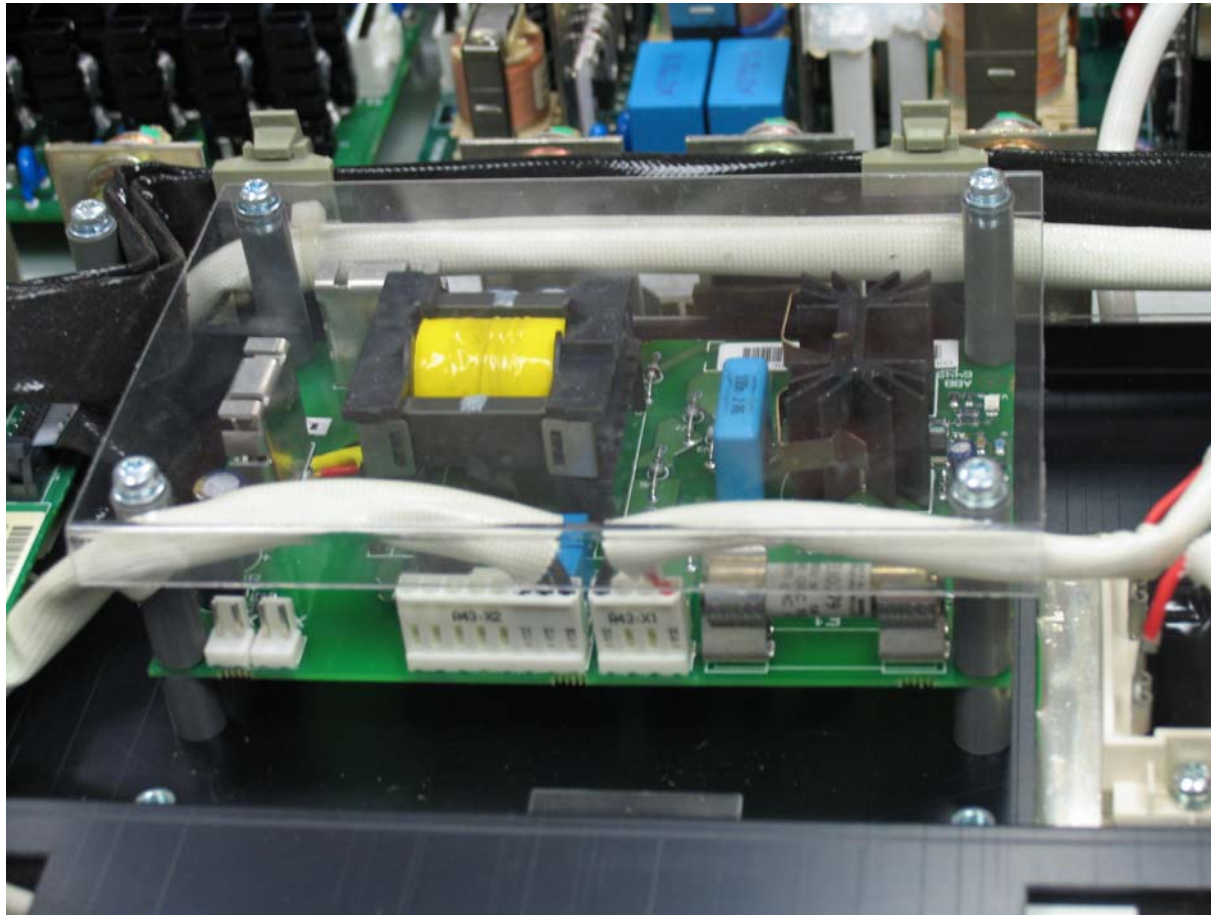
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Firing Board Power Supply



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Gate Firing Power Supply



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Interface Board



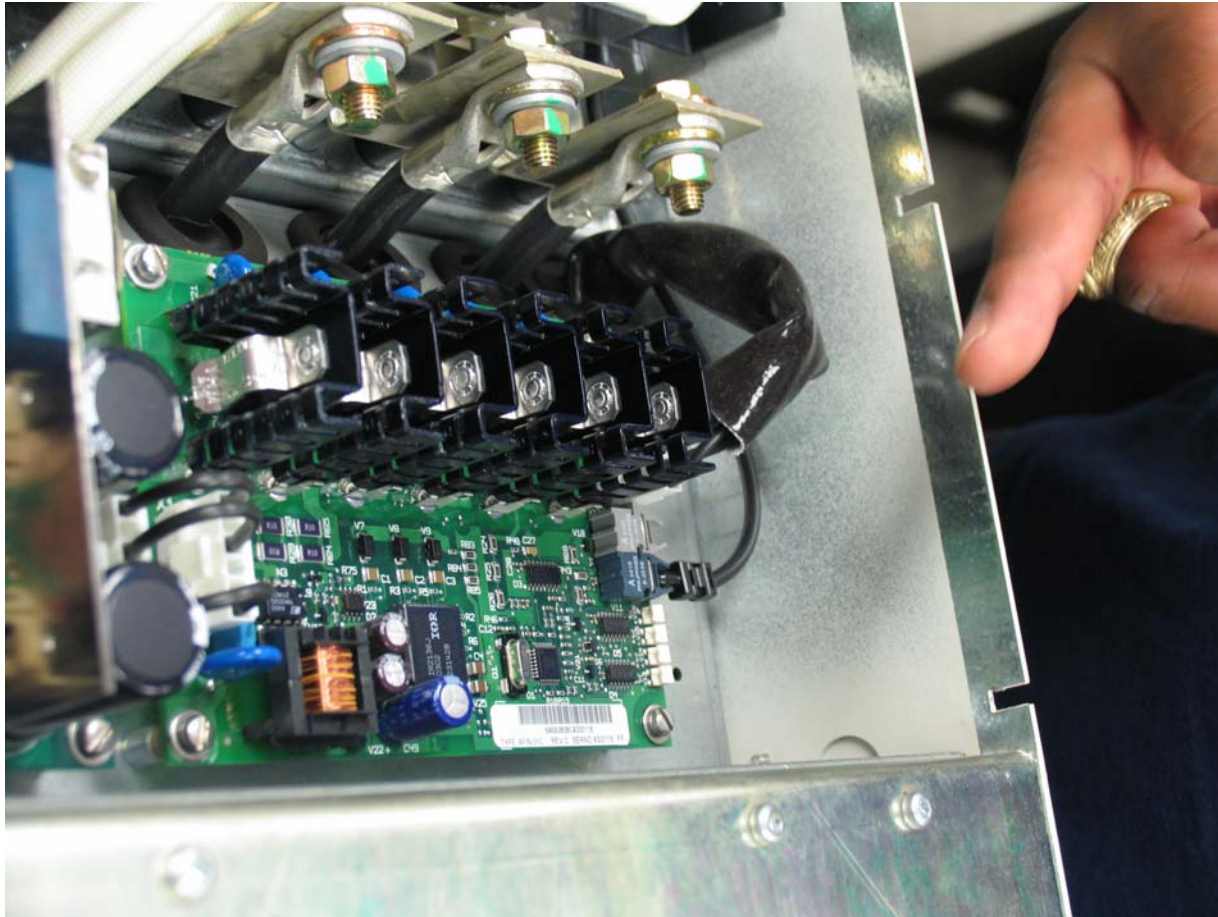
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Fan Interface Board



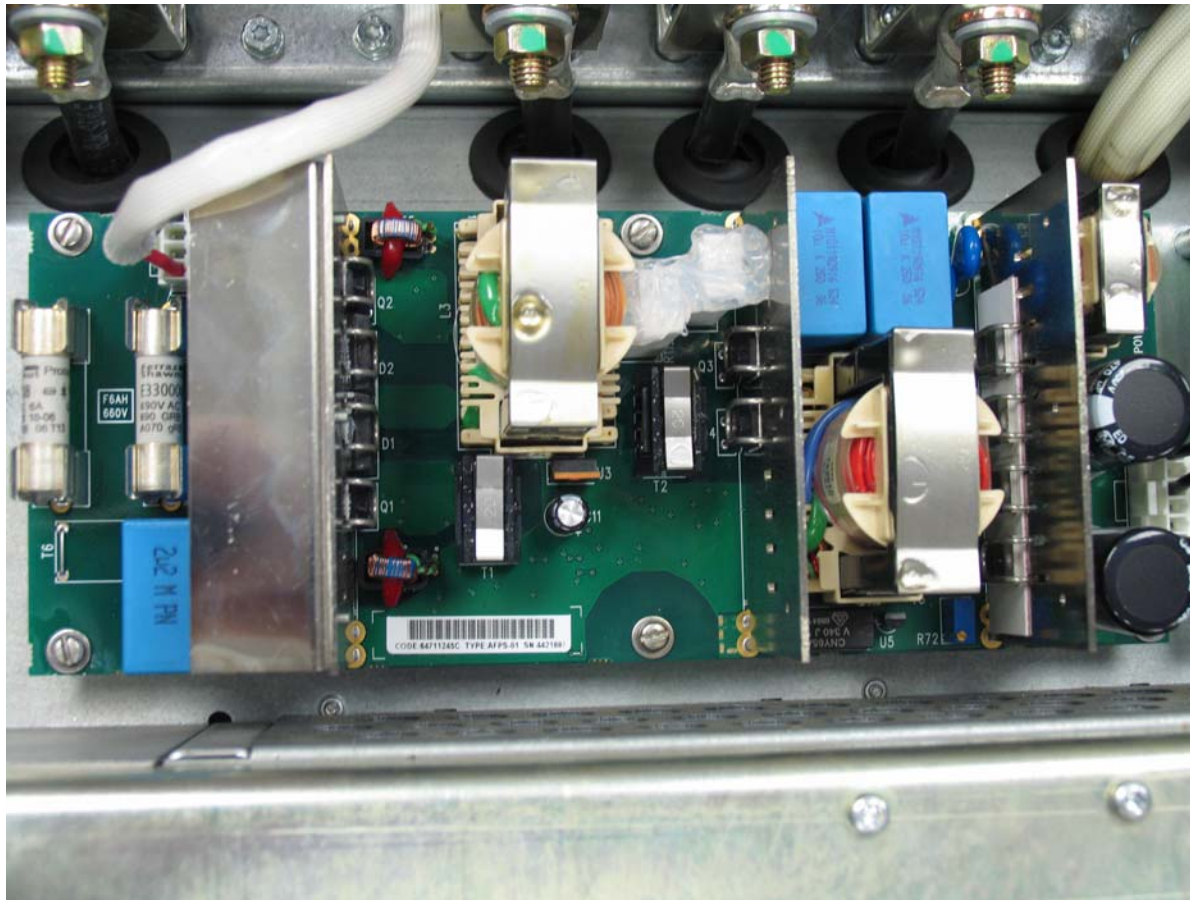
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Fan Power Supply Board



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Multi-Bridge Configuration

450 kW

600 mm



400 mm

900 kW

1500 mm



600 mm

1350 kW

2000 mm



800 mm

2700 kW

4000 mm



1600 mm

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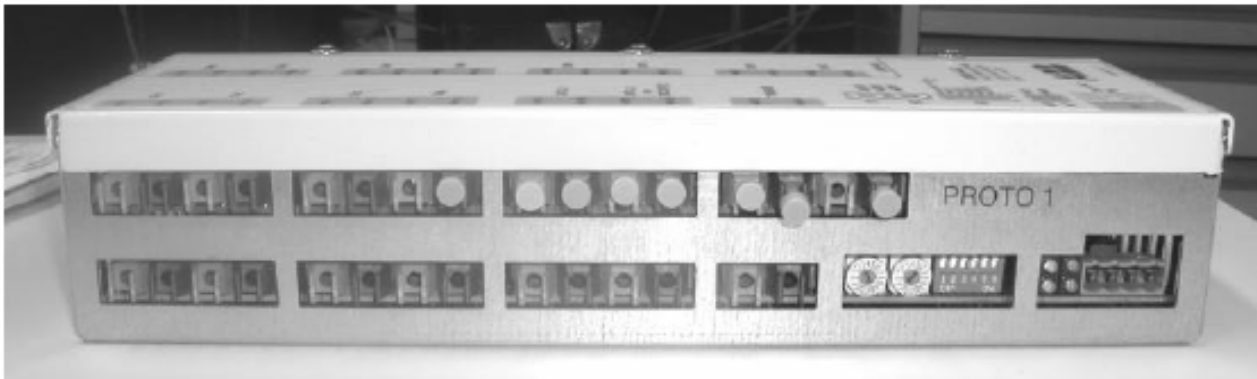


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Branching Unit

- Includes parallel connection support for 2...12 inverter modules.
- Basic board supports 1...4 inverter and with APEB-84C option board up to 12.
- APBU-44 includes fast data logger. Data can be uploaded via PPCS link to be analysed. This function can be used to find faulty component in the main circuit.



APBU-44 Branching Unit Layout

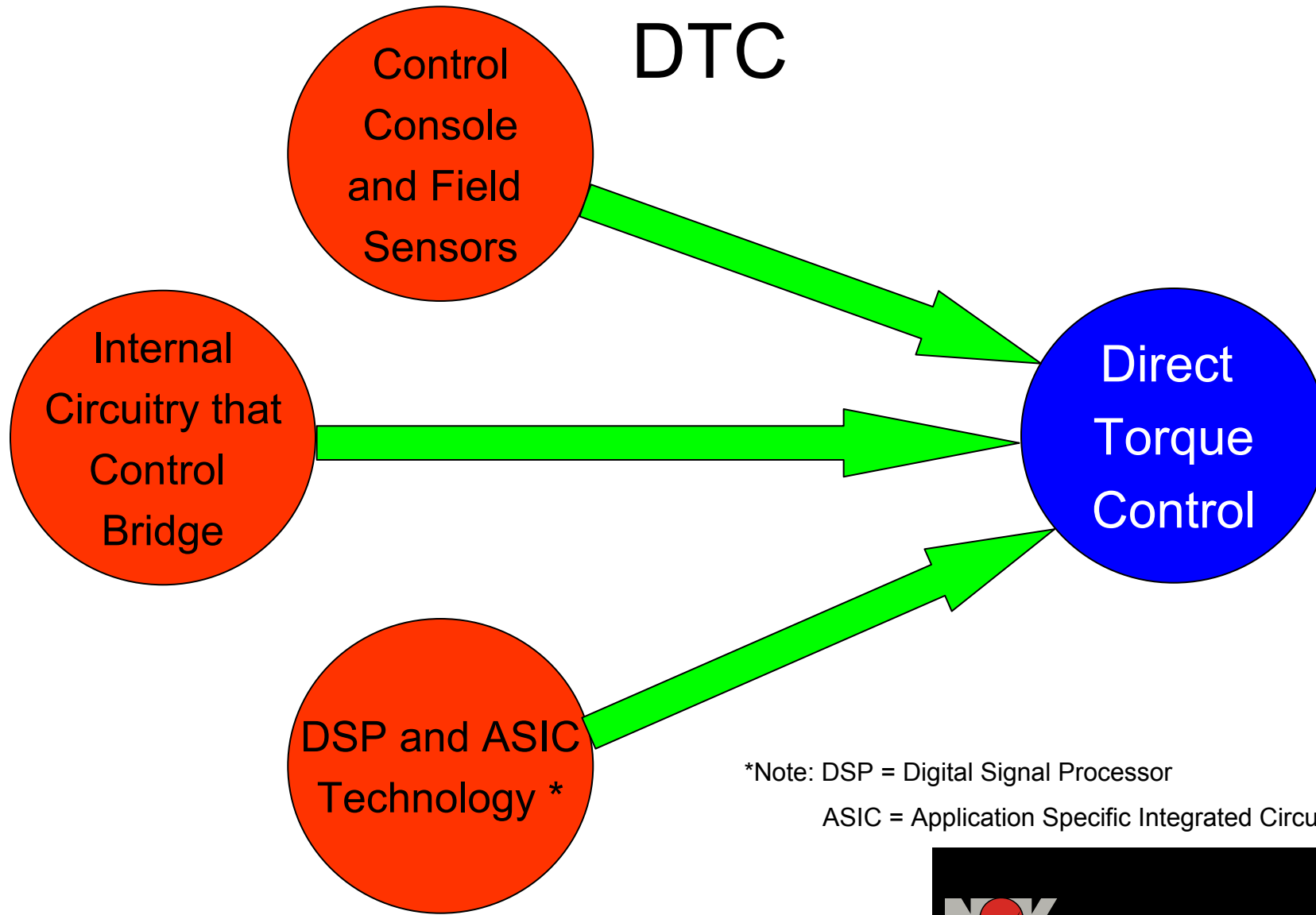
AC Drives for Drilling Applications

DTC – Direct Torque Control

1. Encoder not needed for many applications
2. Excellent torque performance
3. Minimize process disturbances
4. Elimination of resonance problems
5. Quiet operation
6. Broad application coverage

AC Drives for Drilling Applications

DTC

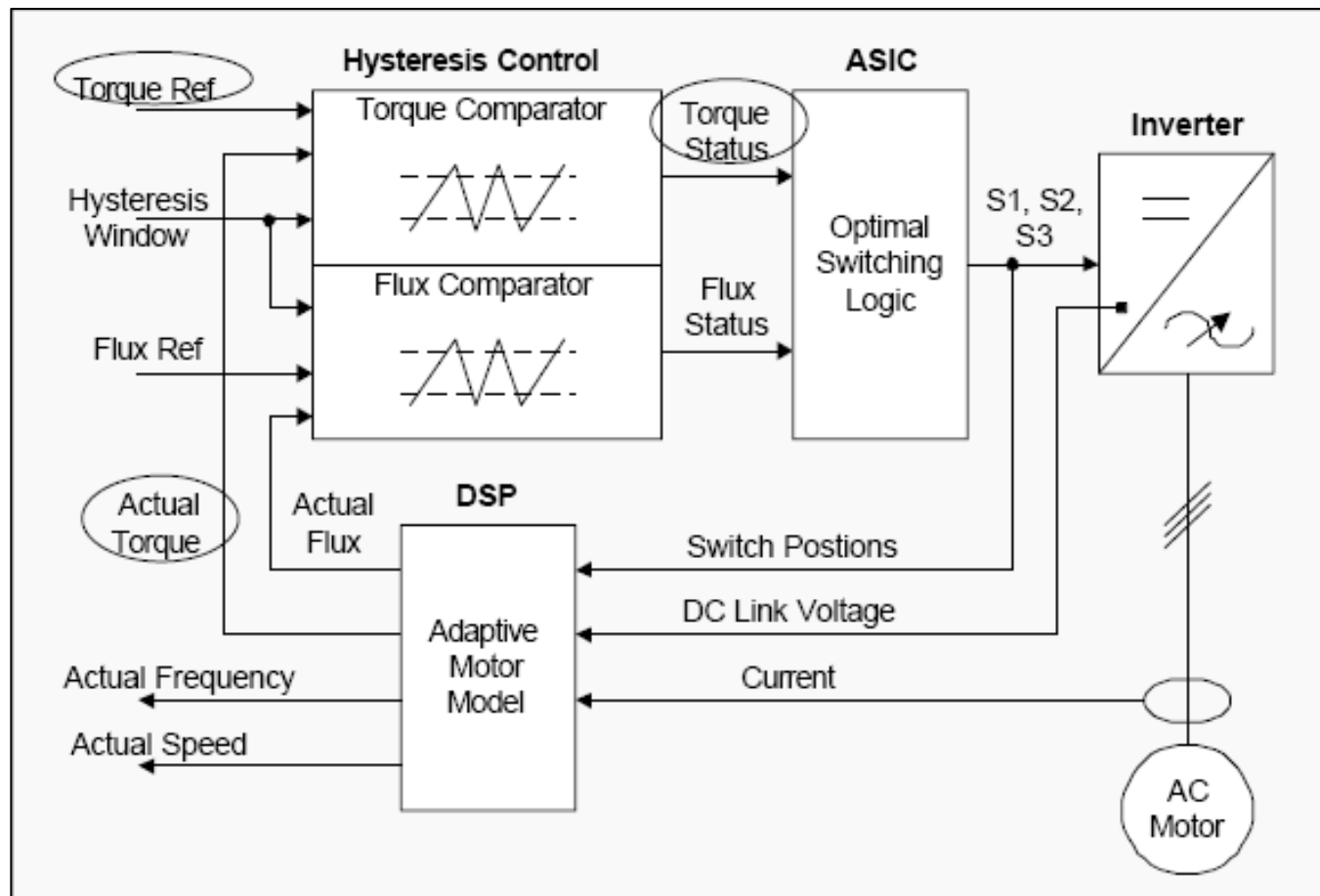


*Note: DSP = Digital Signal Processor

ASIC = Application Specific Integrated Circuit

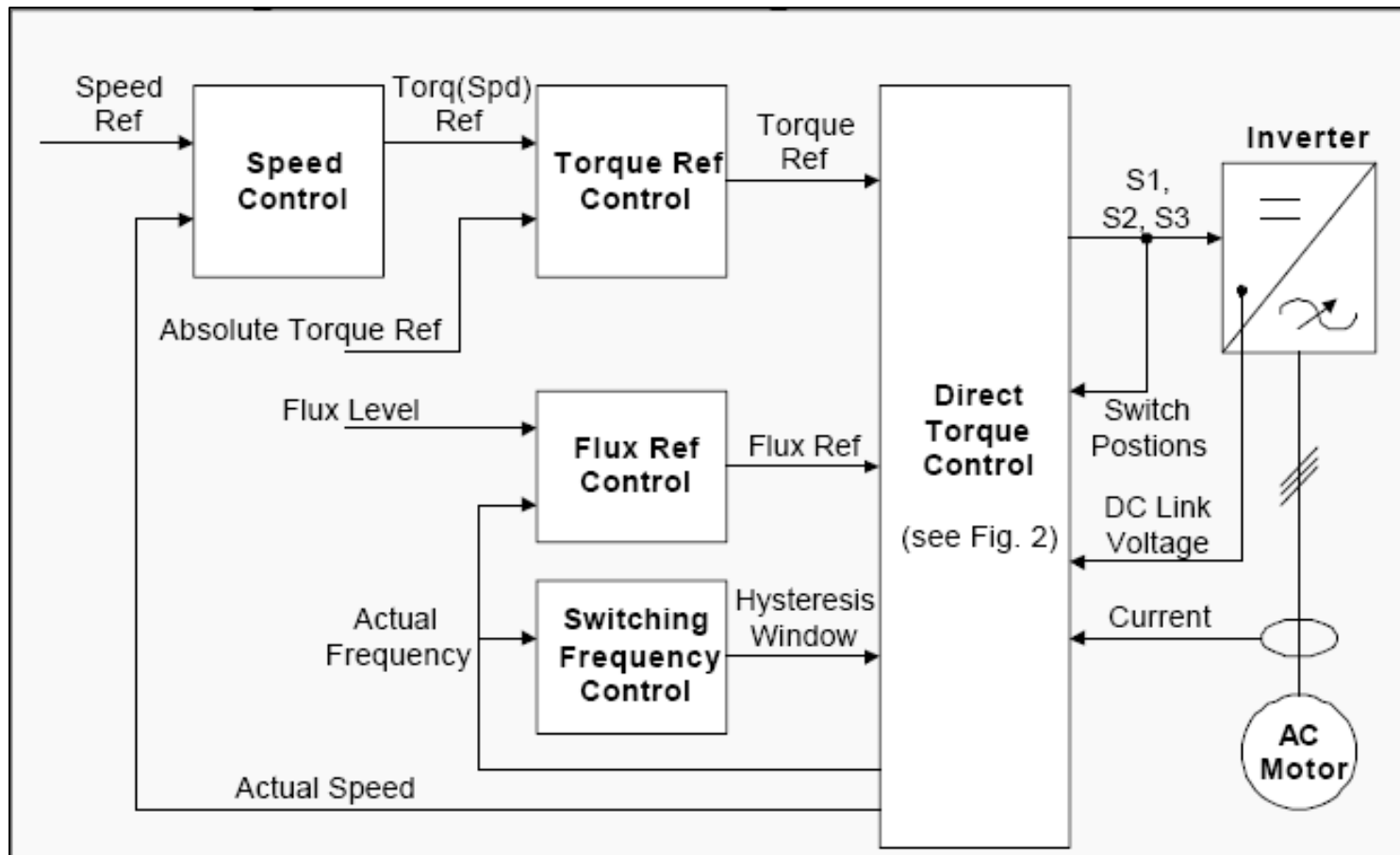
AC Drives for Drilling Applications

Basic Direct Torque Control Scheme



AC Drives for Drilling Applications

Complete Direct Torque Drive Control



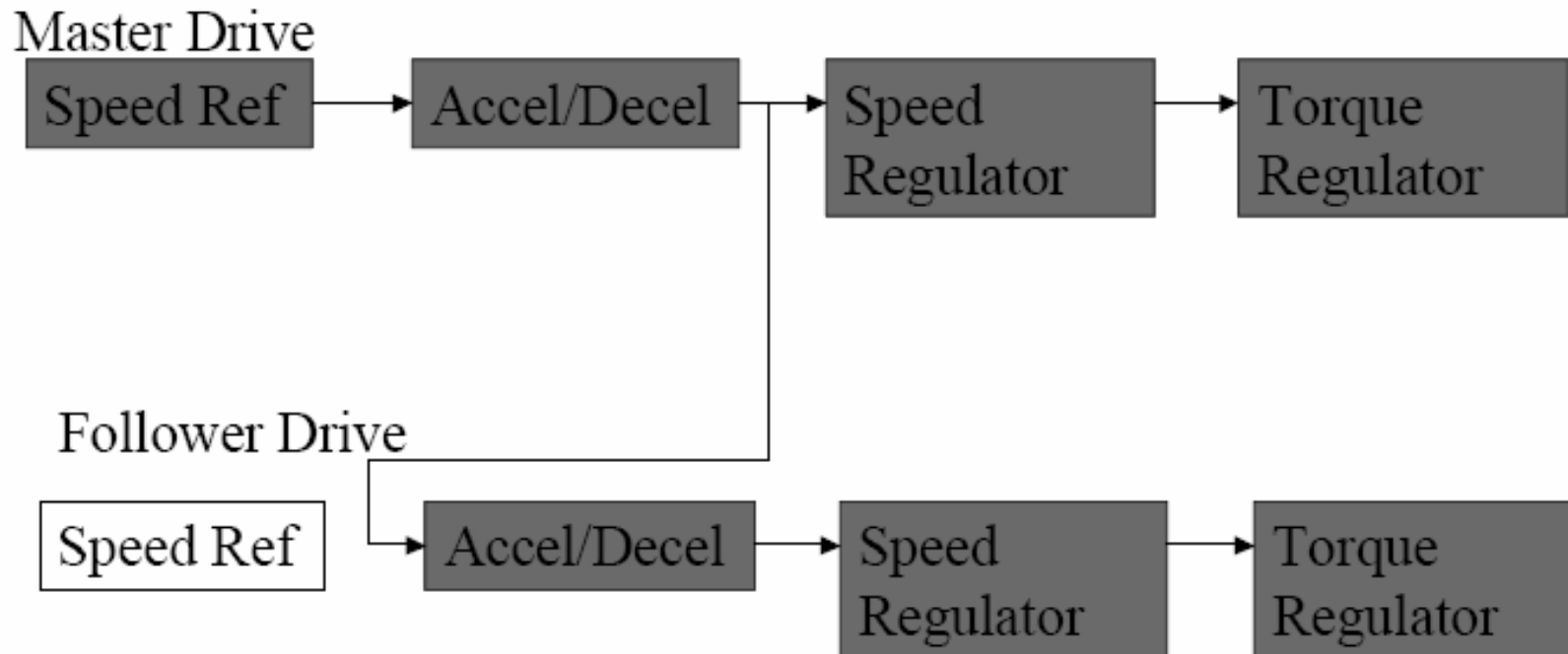
AC Drives for Drilling Applications

Master Follower Configuration

- Master Drive Configurations
 - Speed Regulated
 - Torque Regulated
- Follower Drive Configurations
 - Speed Follower
 - Used when motors are NOT coupled together
 - Speed Follower w/ Droop possible
 - Used when motors are loosely coupled together
- Torque Follower
 - Used when motors are tightly coupled together
 - National Oilwell Varco Configuration
 - Master – Speed Regulated
 - Follower – Torque Follower

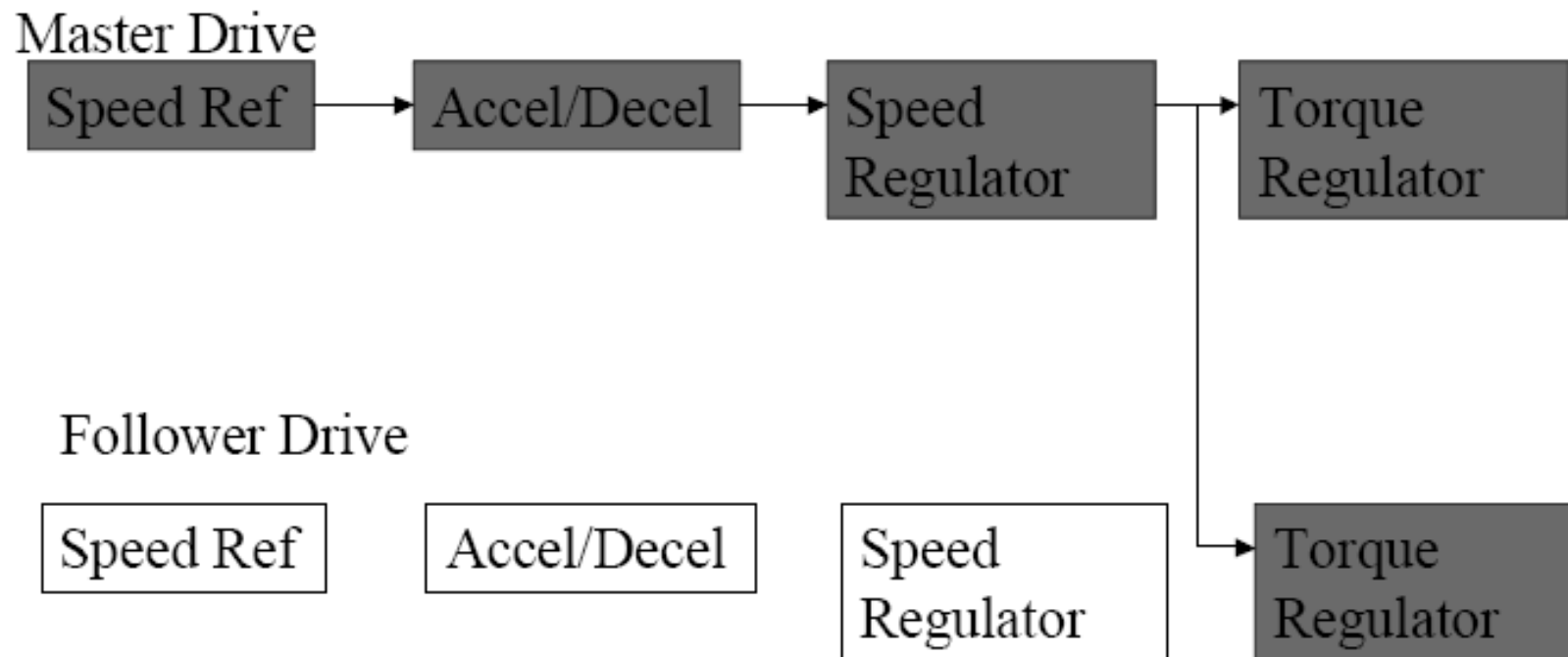
AC Drives for Drilling Applications

Master Follower – Speed Follower



AC Drives for Drilling Applications

Master Follower – Torque Follower



AC Drives for Drilling Applications

Master Follower – Fiber Optic Connections

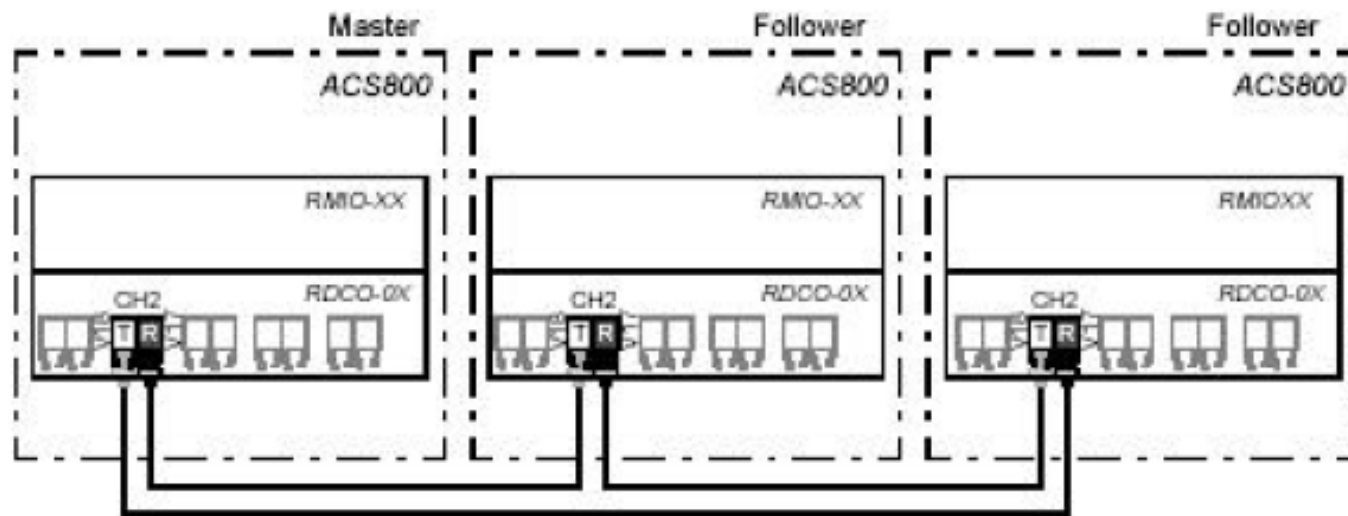
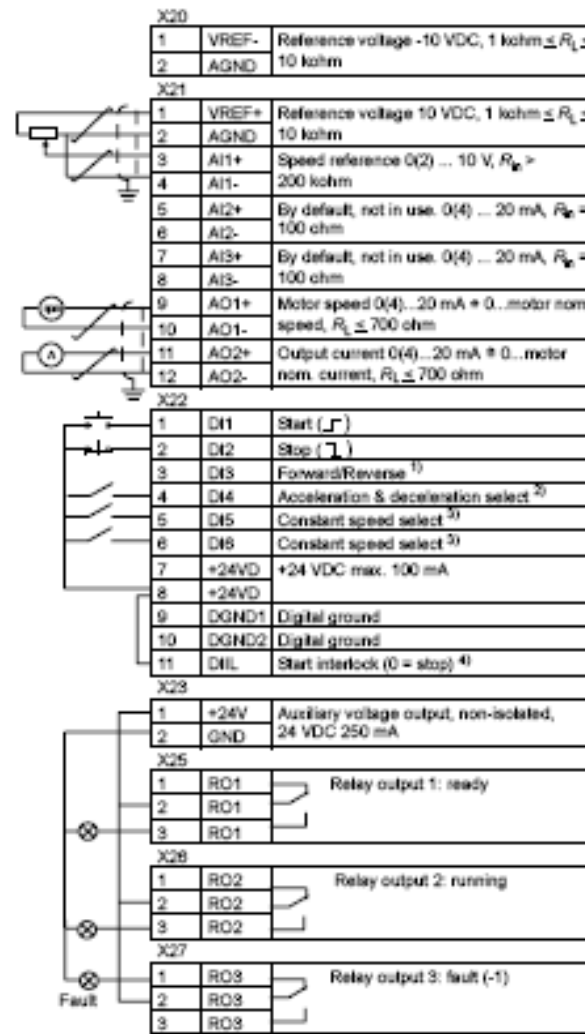


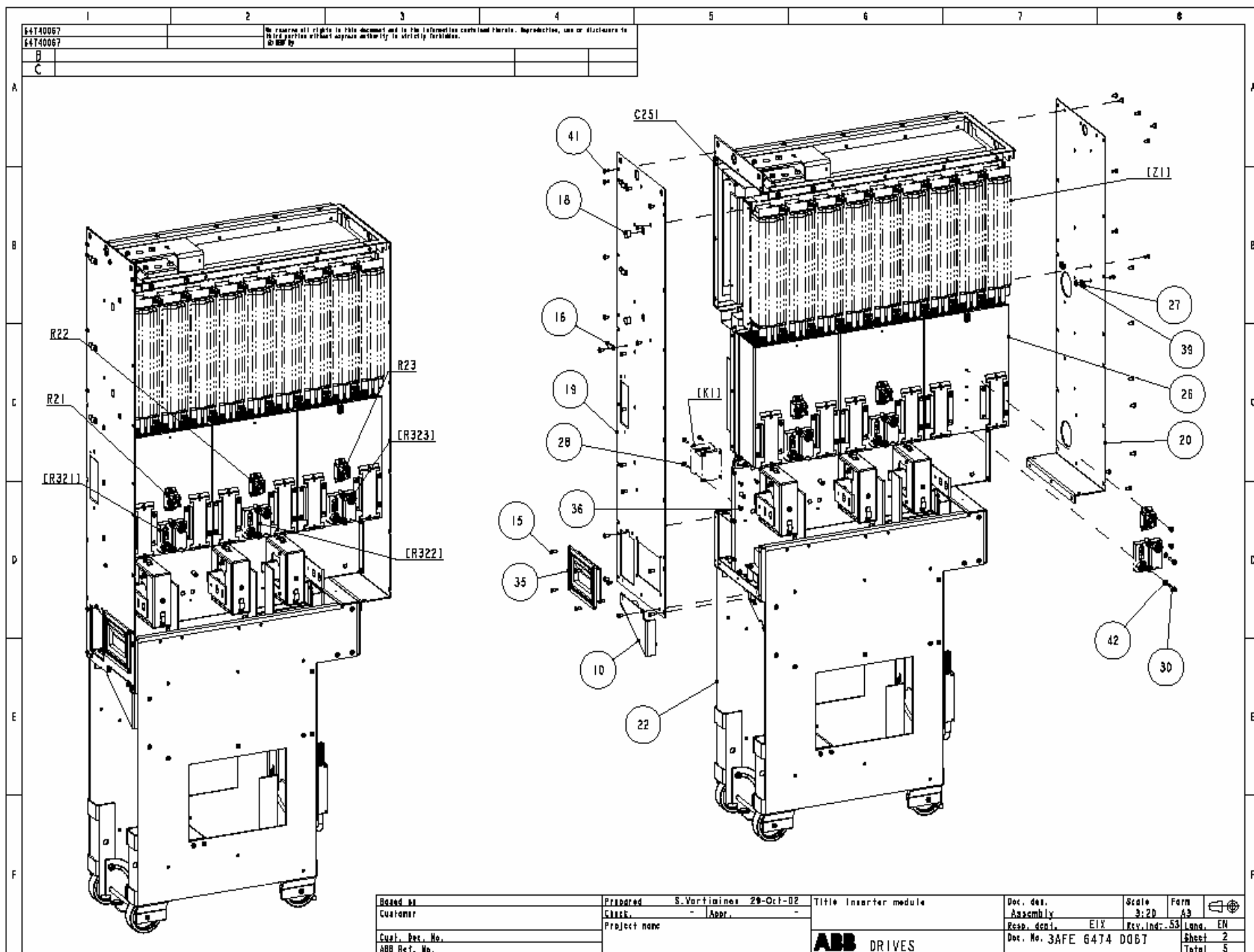
Figure 2. Connections. T = Transmitter, R = Receiver, RMIO = I/O and Control Board. (Please note that channels CH0/CH2/CH3 are located on the optional RDCO-0x board.)

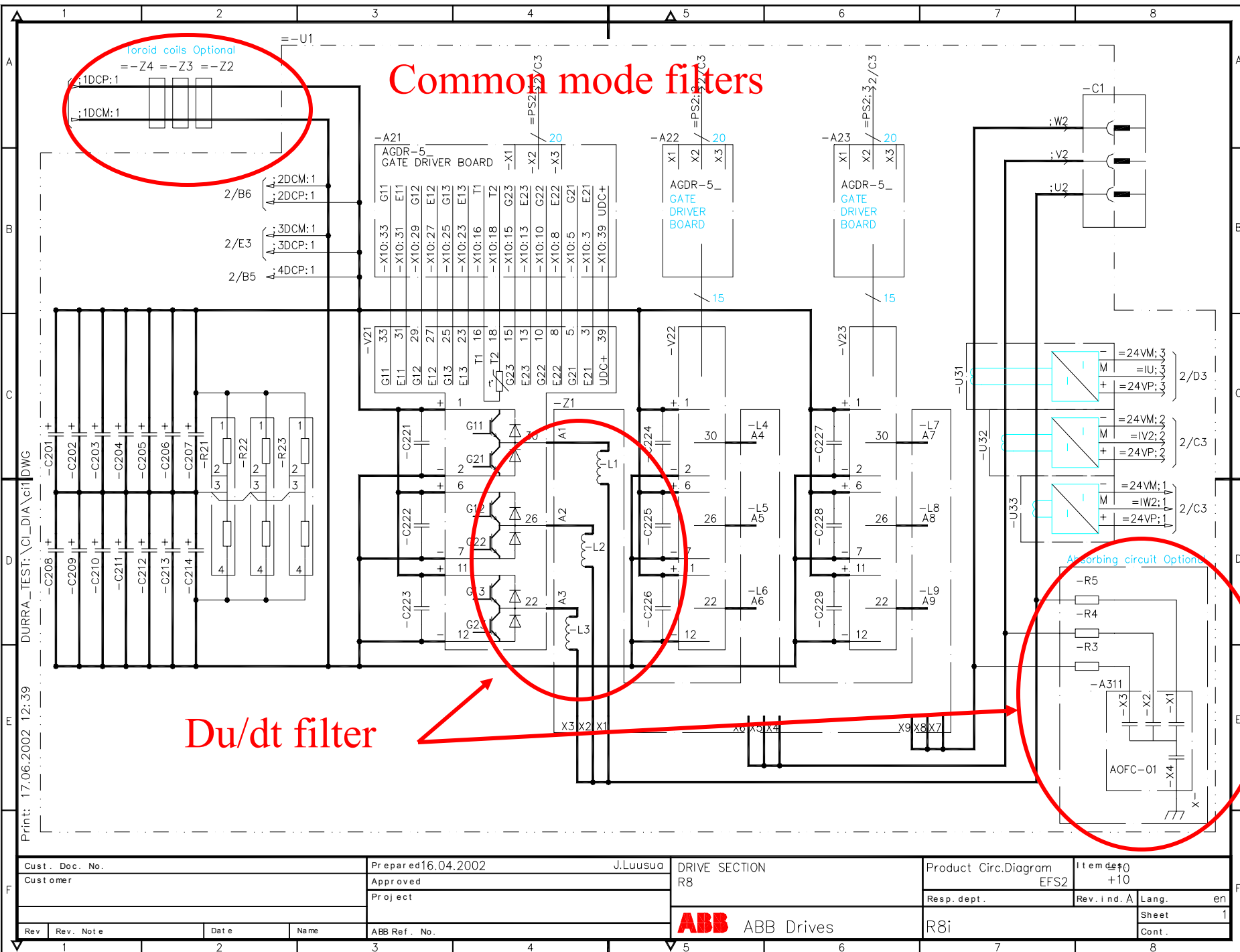
AC Drives for Drilling Applications

Control Wiring Connections

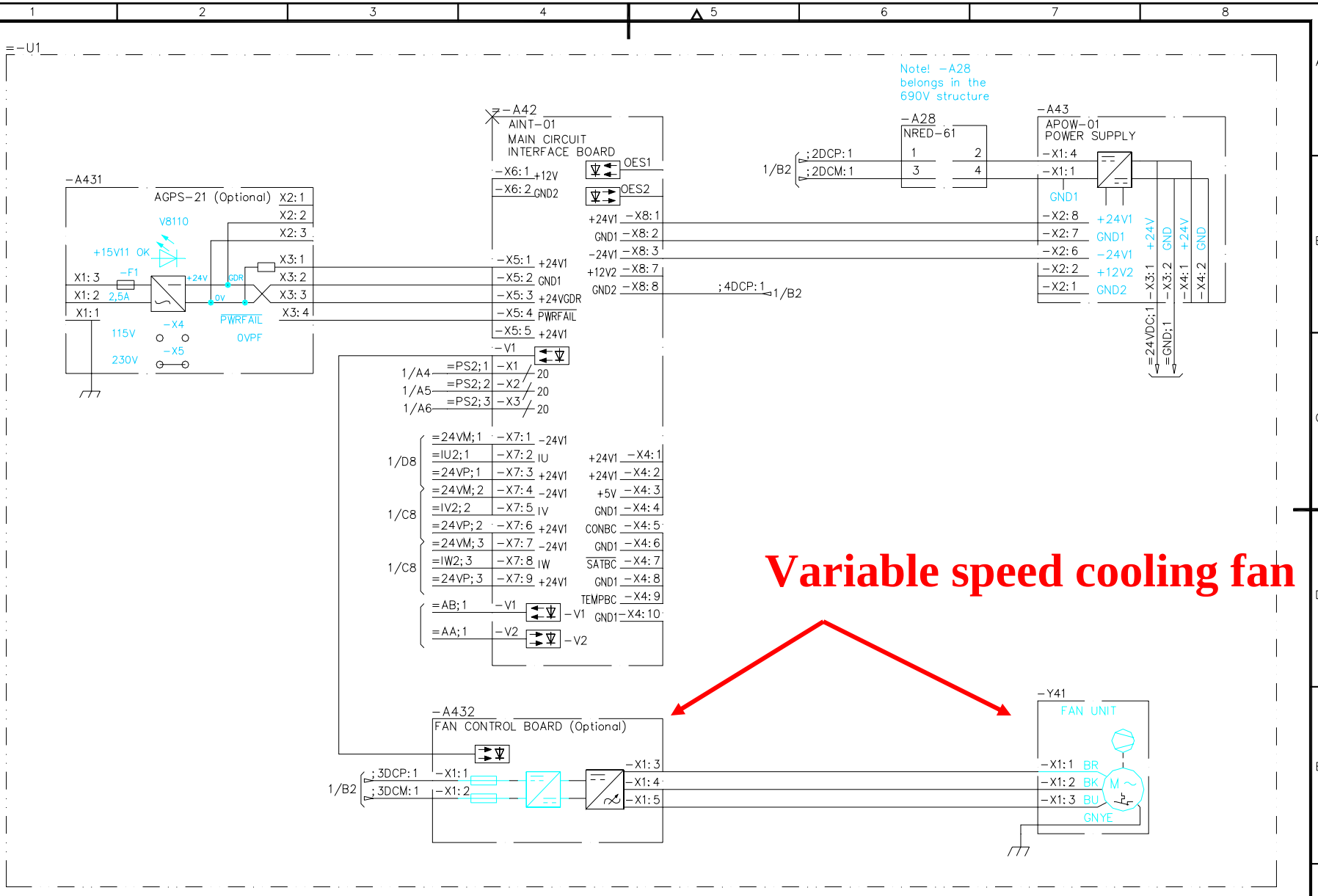


R8i Internal Circuit Diagram





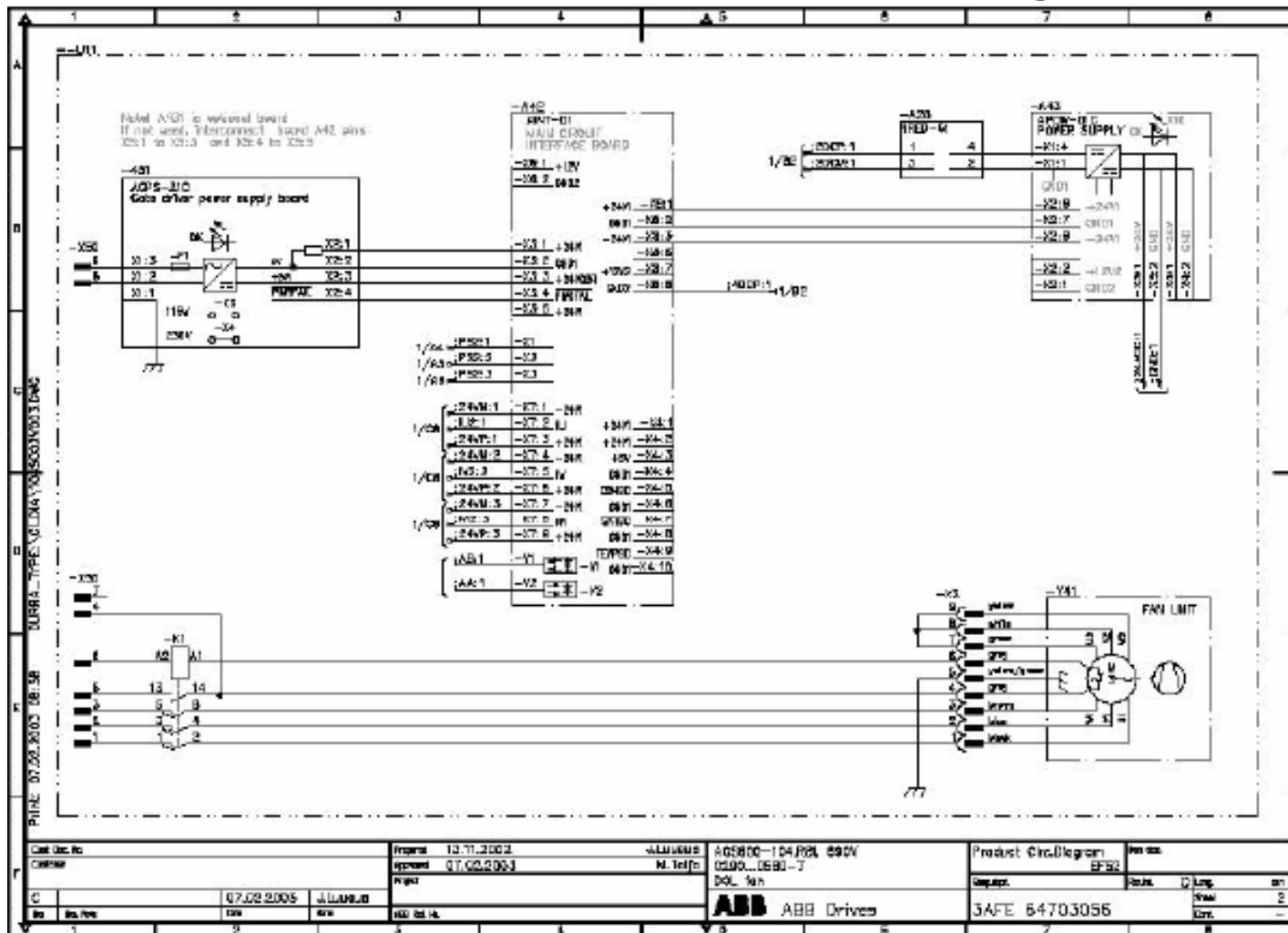
Print: 24.06.2002 13:43 DURRA_TEST: \OL\DI\A\c\4.DWG

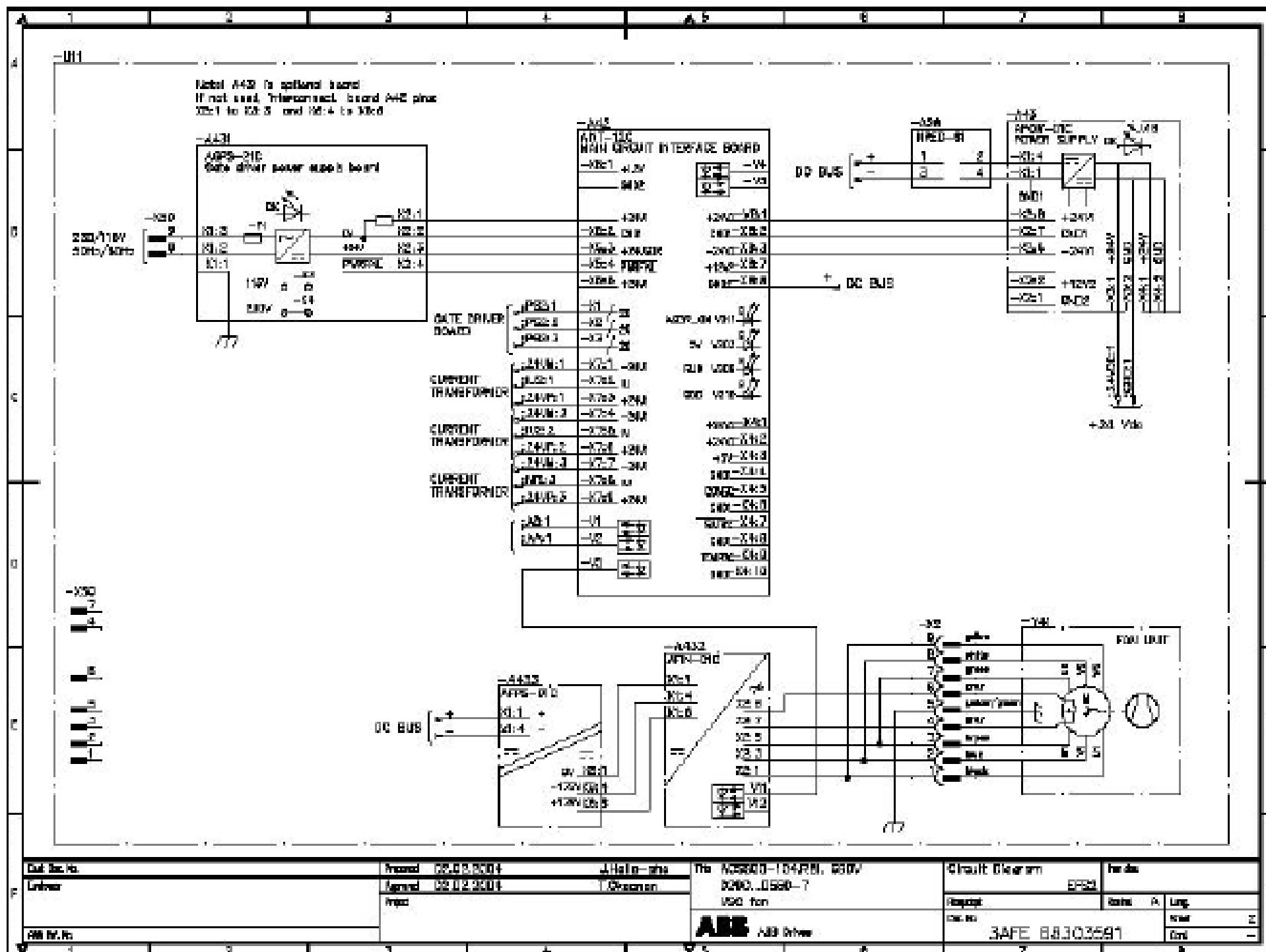


Cust. Doc. No.		Prepared 24.04.2002		J.Luusua		STRABW MODULE		Product Circ. Diagram		Item des 10	
Customer		Approved				R8		EFS2		+10	
		Project				MODULE PROTO		Resp. dept.		Rev. ind. A	
						ABB Drives		R8i		Lang. en	
Rev		Rev. Note		Date		Name		Sheet		2	
1				2		3		4		Cont.	

AC Drives for Drilling Applications

R8i Circuit Board Wiring

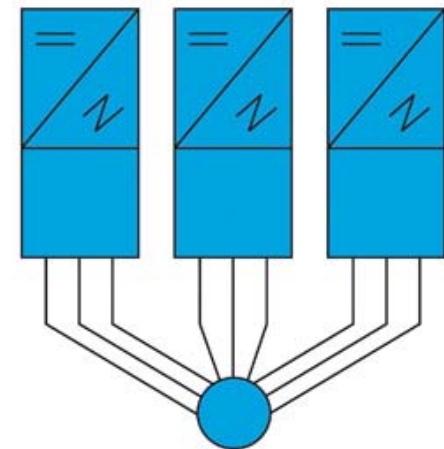
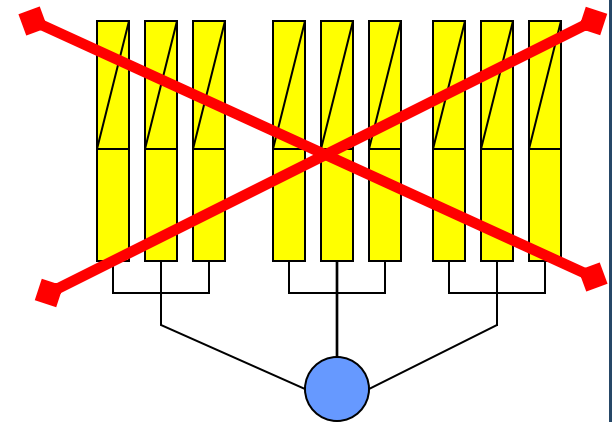






Redundancy

- Built-in redundancy through parallel connected modules
- Each module is a complete three-phase inverter
- Enables running with partial load if one module fails
- Provides for higher drive availability and greater process uptime
- Unique in drives - not available in previous generation ABB drives or in existing competitors' drives



Reduced Run Function with ACS800

- **Reduced Run Function with APBU-44**

It is coming after the 2...12 x R8i basic support

If one inverter module is broken:

- isolate broken inverter module
- drive diagnostics indicates that one inverter module is missing
- user's must accept the permission to continue run with limited maximum current
- **Start the drive!**

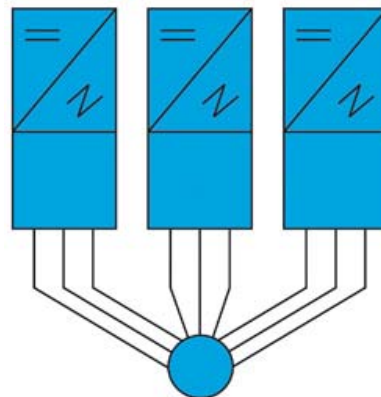


ABB multidrive: drive control unit

- Separate control cabinet for R8i - 12xR8i
- One cabinet size, 300 mm (1ft) wide, arc fault protected
 - Includes space for two inverter controls with options
 - Components are located on fixed assembly plate and in a hinged frame (one or two units in a cabinet)
 - Cable exit and entry in same cabinet
 - DC busbar joint can be made in same cabinet

ABB multidrive: drive control unit

- **Basic design concept**
- Common DC busbar
- Single power line connection
- Shared energy and motor-to-motor braking without braking chopper or regenerative supply unit
- Reduced line current
- Common braking resourced to several drives
- Energy savings
- Savings in cabling, installation and maintenance costs
- Does not require use of separate MCC

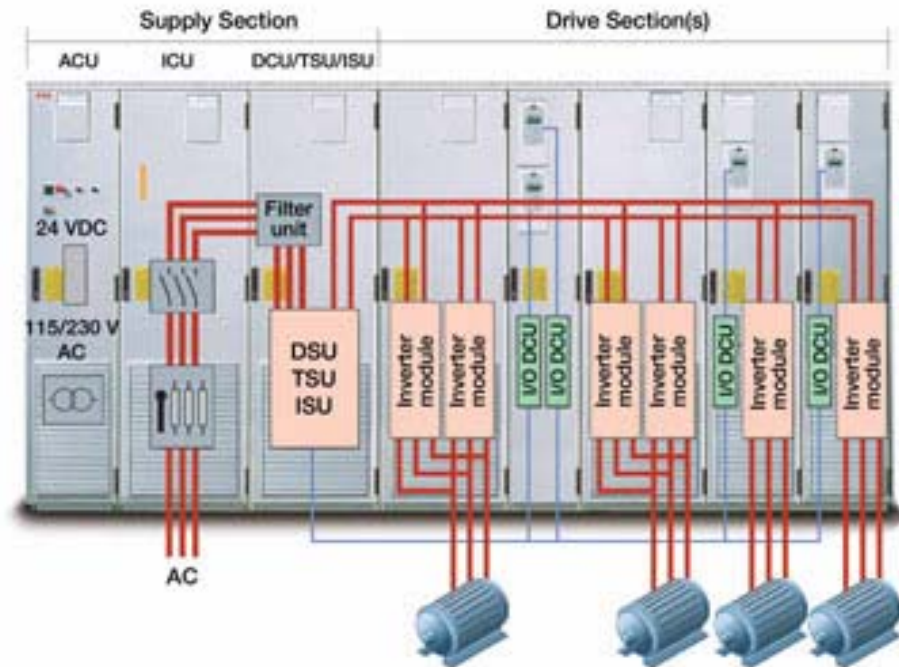
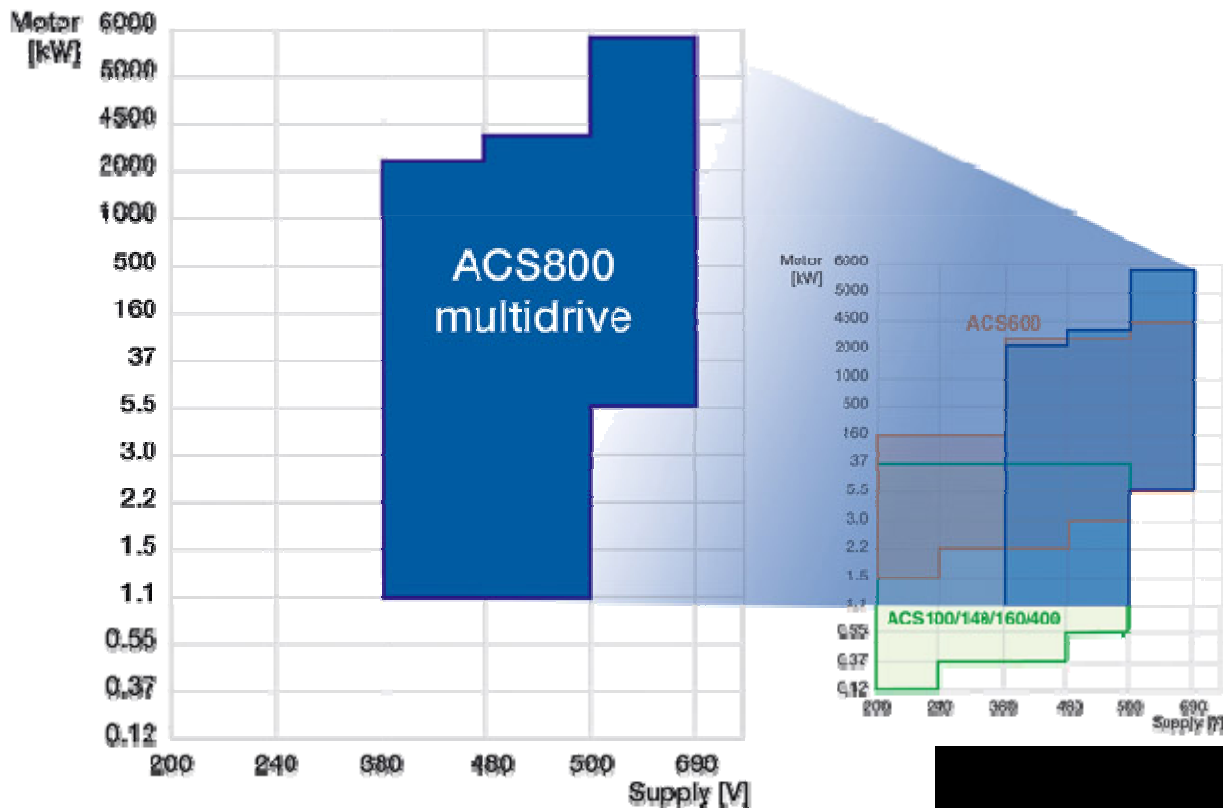


ABB multidrive: drive control unit

- 1.5 - 5600 kW (1 – 7000HP) Motor Inverter
- 80 - 5400kW (100 – 6500HP) Line Inverter
- 185 - 4200 kW (200 – 5600HP) Diode supply
- 640 - 6000 kW (800 – 7500HP) Thyristor supply



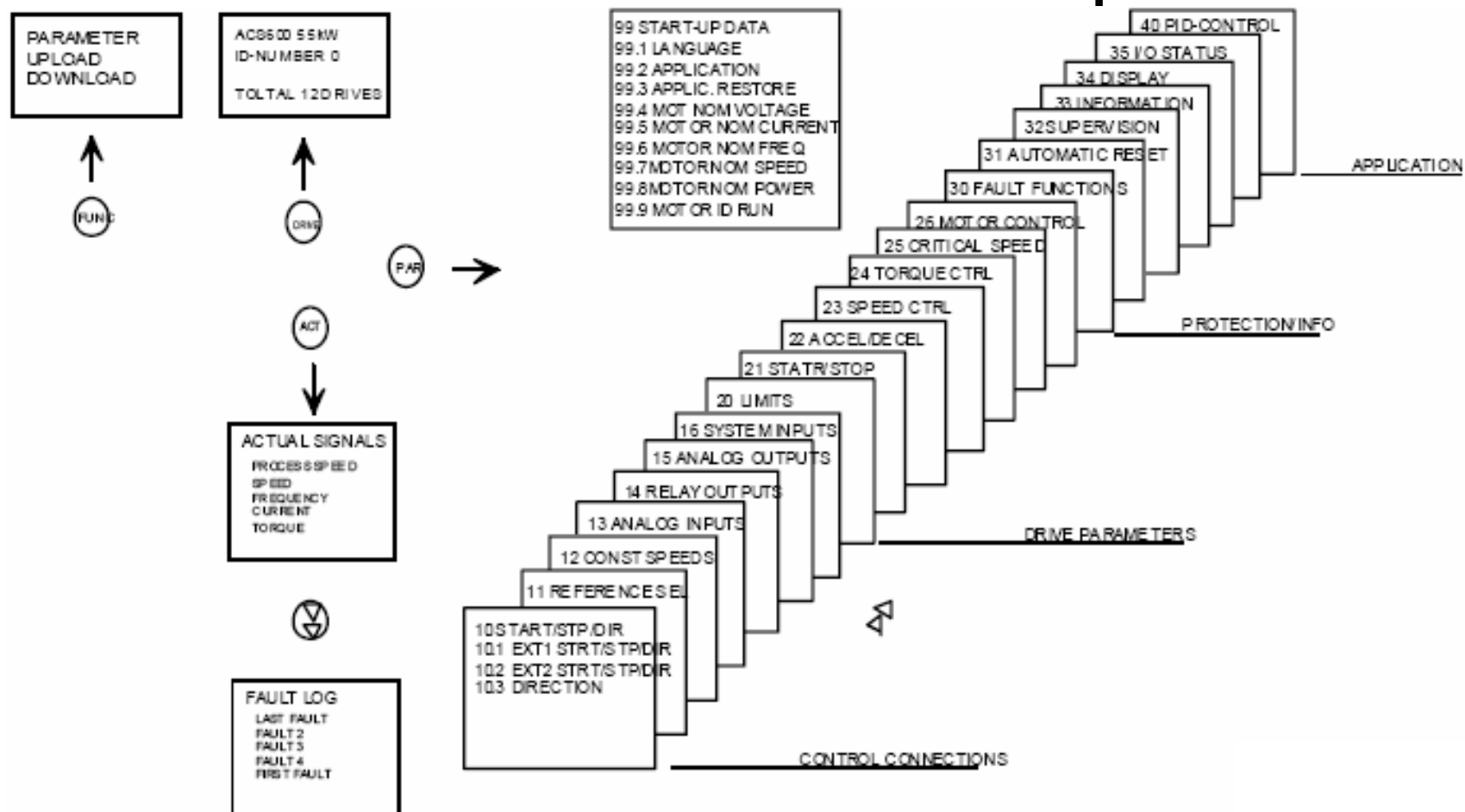
AC Drives for Drilling Applications

Programming the Drive

- There are Six Macros available with the Software
 - Factory Macro
 - Hand/Auto Macro
 - PID Macro
 - Torque Control Macro
 - Sequential Control Macro
 - User Macro One
- Four Menu Groups of Actual Signals
 - 01 Basic Signals
 - 02 Speed and Torque References
 - 03 Fieldbus Monitoring
 - 04 Adaptive Programming
- 35 Programming Menu Groups
- Group Data 99
 - Start Up Data

AC Drives for Drilling Applications

Parameter Road Map



AC Drives for Drilling Applications

Parameter Set 99 – Start-Up Data

- **99.01 Language**
 - Selects the language display
- **99.02 Application Macro**
 - Set the Macro used by the drive
- **99.03 Application Restore**
 - The saved application is restored to the drive memory
- **99.04 Motor CTRL Mode**
 - Defines if the drive will run the motor in Scalar or DTC (Direct Torque Control)
- **99.05 Motor NOM Voltage**
 - This should reflect the motor nameplate voltage
- **99.06 Motor NOM Current**
 - This should reflect the motor nameplate current
- **99.07 Motor NOM FREQ**
 - This should reflect the motor nameplate frequency
- **99.08 Motor NOM Speed**
 - This should reflect the motor nameplate speed
- **99.09 Motor NOM Power**
 - This should reflect the motor nameplate power
- **99.10 Motor ID Run Mode**
 - Defines the type of motor identification run (ID Magnetization, Standard, and Reduced)
- **99.11 Device Name**
 - Display the Drive or Application Name

AC Drives for Drilling Applications

Parameter Set 98 – Option Modules

- **98.01 Encoder Module**
 - Sets the Encoder module on the drive
- **98.02 COMM Module Link**
 - Sets the Communication Module
- **98.03 DI/O EXT Module 1**
 - Sets the first Digital Input/Output combination Module
- **98.04 DI/O EXT Module 2**
 - Sets the second Digital Input/Output combination Module
- **98.05 DI/O EXT Module 3**
 - Sets the third Digital Input/Output combination Module
- **98.06 AI/O EXT Module**
 - Sets the Analog Input/Output combination Module
- **98.07 COMM Profile**
 - Defines the type of fieldbus or drive communication used (Profibus DP, Canbus, Device net, etc..)
- **98.09 DI/O EXT 1 DI FUNC**
 - Defines how the Digital Inputs will be used in the drive
- **98.10 DI/O EXT 2 DI FUNC**
 - Defines how the Digital Inputs will be used in the drive
- **98.11 DI/O EXT 3 DI FUNC**
 - Defines how the Digital Inputs will be used in the drive
- **98.12 AI/O Motor TEMP**
 - Defines the Analog Input signals for thermal devices

AC Drives for Drilling Applications

Monitoring Parameter Set 01 – Basic Signals

- **01.01 Process Variable**
 - Set by the menu group 34 Process Variable (1=1)
- **01.02 Speed**
 - Motor Speed in R.P.M. (+20000 to -20000 = +100% to -100%)
- **01.03 Frequency**
 - Calculated Output Frequency (-100 = -1Hz, +100 = 1Hz)
- **01.04 Current**
 - Measured Motor Current (10 = 1Amp)
- **01.05 Torque**
 - Calculated Motor Torque (10000 = 100%, -10000 = 100%)
- **01.06 Power**
 - Motor Power (10000 = 100%, -10000 = 100%)
- **01.07 DC Bus Voltage**
 - Monitors the Voltage on the Capacitor Bank (1 = 1V DC)
- **01.08 Mains Voltage**
 - Calculated AC Supply Voltage (1 = 1 Volt AC)
- **01.09 Output Voltage**
 - Calculated Motor Voltage (1 = 1 Volt AC)
- **01.10 ACS 800 Temp**
 - Measured Heatsink Temperature (1 = 1°Celsius)

AC Drives for Drilling Applications

Monitoring Parameter Set 01 – Basic Signals

- **01.11 External Reference 1**
 - Monitors the first external references provided by the user (1 = 1 R.P.M.)
- **01.12 External Reference 2**
 - Monitors the second external references provided by the user (1 = 1 R.P.M.)
- **01.13 CTRL Location**
 - Displays the source of the Control Signals (1,2 = Local, 3 = External 1, 4 = External 2)
- **01.14 OP Hour Counter**
 - Hour Counter of the Control Board Powered up (1 = 1 Hour)
- **01.15 Kilowatt Hours**
 - Kilowatt Hour Counter (1 = 1 Kilowatt Hour)
- **01.16 APPL Block Output**
 - Application Block Output (0 = 0%, 10000 = 100%)
- **01.17 DI6-1 Status**
 - Status of the six Digital Inputs (000001 = DI 1 is on, DI2 thru DI6 is off)
- **01.18 AI 1 [V]**
 - Monitors the First Analog Input (1 = 0.001 Volt DC)
- **01.19 AI 2 [mA]**
 - Monitors the Second Analog Input (1 = 0.001 milliamp)
- **01.20 AI 3 [mA]**
 - Monitors the second Analog Input (1 = 0.001 milliamp)

AC Drives for Drilling Applications

Monitoring Parameter Set 01 – Basic Signals

- **01.21 RO3-1 Status**
 - Status of the Relay Outputs (001 = Relay Output 1 is on, Relay Output 2 and 3 are off)
- **01.22 AO 1 [mA]**
 - Value of the first Analog Output 1 (1 = 0.001 milliamp)
- **01.23 AO 2 [mA]**
 - Value of the first Analog Output 1 (1 = 0.001 milliamp)
- **01.24 Actual Value 1**
 - Feedback signal of the PID process (0 = 0%, 10000 = 100%) Needs Parameter 99.02 to be PD CTRL
- **01.25 Actual Value 2**
 - Feedback signal of the PID process (0 = 0%, 10000 = 100%) Same as above
- **01.26 Control Deviation**
 - Deviation of the Ref Signal and fdbk Signal of the PID (0 = 0%, 10000 = 100%) Same as above
- **01.27 Application Macro**
 - Displays the Macro being used (Factory, Hand/Auto, PID, etc...)
- **01.28 AO 1 [mA]**
 - Monitors the First Analog Output (1 = 0.001 milliamp)
- **01.29 AO 2 [mA]**
 - Monitors the Second Analog Output (1 = 0.001 milliamp)
- **01.30 PP1 Temp**
 - Maximum IGBT Temperature of Inverter 1 (1 = 1° Celsius)

AC Drives for Drilling Applications

Monitoring Parameter Set 01 – Basic Signals

- **01.31 PP2 Temp**
 - Maximum IGBT Temperature of Inverter 2 (1 = 1° Celsius)
- **01.32 PP3 Temp**
 - Maximum IGBT Temperature of Inverter 3 (1 = 1° Celsius)
- **01.33 PP4 Temp**
 - Maximum IGBT Temperature of Inverter 4 (1 = 1° Celsius)
- **01.34 Actual Value**
 - Process Value of the PID regulator (0 = 0%, 10000 = 100%)
- **01.35 Motor 1 Temp**
 - Measures temperature of Motor 1 (1 = 1° Celsius)
- **01.36 Motor 2 Temp**
 - Measures temperature of Motor 2 (1 = 1° Celsius)
- **01.37 Motor Temp EST**
 - Estimated Motor Temperature (1 = 1° Celsius)
- **01.38 AI 5 [mA]**
 - Read from the first analog input of the expansion module (1 = 0.001 milliamp)
- **01.39 AI 6 [mA]**
 - Read from the second analog input of the expansion module (1 = 0.001 milliamp)
- **01.40 DI7-12**
 - Status of six Digital Inputs on an expansion module (1=1)

AC Drives for Drilling Applications

Monitoring Parameter Set 01 – Basic Signals

■ 01.41 EXT RO Status

- Status of the Relay Outputs on an expansion board (1=1)

■ 01.42 Process Speed Rel

- The actual Absolute Maximum Speed of the motor (1 = 1) Parameter 99.04 must be in Scalar

■ 01.43 Motor Run Time

- Motor on time counter (1 = 1 Hour)

■ 01.44 Fan On Time

- Cooling Fan on time

■ 01.45 CTRL Board Temp

- Measures temperature of the control board

AC Drives for Drilling Applications

Monitoring Parameter Set 02 – Speed and Torque References

- 02.01 Speed Ref 2
 - Limited Speed Reference (0 = 0%, 20000 = 100%)
- 02.02 Speed Ref 3
 - Ramped and Shaped speed reference (20000 = 100%)
- 02.09 Torque Ref 2
 - Speed Controller Output (0 = 0%, 10000 = 100%)
- 02.10 Torque Ref 3
 - Torque Reference (10000 = 100%)
- 02.13 Torque Used Ref
 - Torque Reference after Frequency, Voltage, and Torque limiters (10000 = 100%)
- 02.14 Flux Ref
 - Flux Reference in percent (10000 = 100%)
- 02.17 Speed Estimated
 - Estimated motor speed (20000 = 100%)
- 02.18 Speed Measures
 - Measured speed of the motor based off the encoder (20000 = 100%)

AC Drives for Drilling Applications

Monitoring Parameter Set 03 – Fieldbus Signals

- **03.01 Main CTRL Word**
 - a 16 bit data word (Main Control data signals that control the drive)
- **03.02 Main Status Word**
 - a 16 bit data word (Main Status data signals that detail the status of the drive)
- **03.03 Aux Status Word**
 - a 16 bit data word (Auxiliary data signals that contain status of the drive)
- **03.04 Limit Word 1**
 - a 16 bit data word (The torque limit reference from the PLC)
- **03.05 Fault Word 1**
 - a 16 bit data word (Fault signals from the drive)
- **03.06 Fault Word 2**
 - a 16 bit data word (Fault signals from the drive)
- **03.07 System Fault**
 - a 16 bit data word (Hardware Fault signals within the drive)
- **03.08 Alarm Word 1**
 - a 16 bit data word (Alarm signals from the drive)
- **03.09 Alarm Word 2**
 - a 16 bit data word (Alarm signals from the drive)
- **03.11 Follower MCW**
 - a 16 bit data word (Main Control Word sent to the slave drive in a Master Follower configuration)

AC Drives for Drilling Applications

Monitoring Parameter Set 03 – Fieldbus Signals

- **03.12 INT Fault Info**
 - a 16 bit data word (Internal Fault data from the Drive)
- **03.13 Aux Status Word 3**
 - a 16 bit data word (Status data signals that detail the status of the drive)
- **03.14 Aux Status Word 4**
 - a 16 bit data word (Status data signals that contain status of the drive)
- **03.15 Fault Word 4**
 - a 16 bit data word (Fault data signals from the drive)
- **03.16 Alarm Word 4**
 - a 16 bit data word (Alarm signals from the drive)
- **03.17 Fault Word 5**
 - a 16 bit data word (Fault signals from the drive)
- **03.18 Alarm Word 5**
 - a 16 bit data word (Alarm signals from the drive)
- **03.19 INT INIT Fault**
 - a 16 bit data word (Internal Initialization signals from the drive)
- **03.20 Latest Fault**
 - a 16 bit data word (most recent Fault code from the drive)
- **03.21 2.Latest Fault**
 - a 16 bit data word (second most recent Fault code from the drive)

AC Drives for Drilling Applications

Monitoring Parameter Set 03 – Fieldbus Signals

- 03.22 3.Latest Fault
 - a 16 bit data word (Third most recent Fault code from the drive)
- 03.23 4.Latest Fault
 - a 16 bit data word (Fourth most recent Fault code from the drive)
- 03.24 5.Latest Fault
 - a 16 bit data word (Fifth most recent Fault code from the drive)
- 03.25 Latest Warning
 - a 16 bit data word (Most Recent warning from the drive)
- 03.26 2.Latest Warning
 - a 16 bit data word (Second most Recent warning from the drive)
- 03.27 3.Latest Warning
 - a 16 bit data word (Third most Recent warning from the drive)
- 03.28 4.Latest Warning
 - a 16 bit data word (Fourth most Recent warning from the drive)
- 03.29 5.Latest Warning
 - a 16 bit data word (Fifth most Recent warning from the drive)

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AC Drives for Drilling Applications

Monitoring Parameter Set 04 – Adaptive Programming

- **04.01 AI1 Scaled**
 - Value of Analog 1 Scaled (20000 = 10V DC)
- **04.02 AI2 Scaled**
 - Value of Analog 2 Scaled (20000 = 20mA)
- **04.03 AI3 Scaled**
 - Value of Analog 3 Scaled (20000 = 20mA)
- **04.04 AI5 Scaled**
 - Value of Analog 5 Scaled (20000 = 20mA)
- **04.05 AI6 Scaled**
 - Value of Analog 6 Scaled (20000 = 20mA)
- **04.06 DS MCW**
 - Control Word from the Master Drive in a Master Follower configuration (0 - 65535 Decimal)
- **04.07 Master Ref 1**
 - Main Reference 1 from the Master Drive (-32768 to 32767)
- **04.08 Master Ref 2**
 - Main Reference 2 from the Master Drive (-32768 to 32767)
- **04.09 Aux DS Val 1**
 - Main Reference 3 from the Master Drive (-32768 to 32767)
- **04.10 Aux DS Val 2**
 - Main Reference 4 from the Master Drive (-32768 to 32767)
- **04.11 Aux DS Val 3**
 - Main Reference 5 from the Master Drive (-32768 to 32767)

AC Drives for Drilling Applications

Parameter Set 10 – Start, Stop, and Direction

- 10.01 EXT1 STRT/STP/DIR
 - The source for the external Start, Stop, and Direction
- 10.02 EXT2 STRT/STP/DIR
 - The source for the external Start, Stop, and Direction
- 10.03 Ref Direction
 - Sets the direction of the motor
- 10.04 EXT 1 STRT PTR
 - The parameter that defines the external one Start command
- 10.05 EXT 2 STRT PTR
 - The parameter that defines the external two Start command
- 10.06 Jog Speed Select
 - Defines the Digital Input that will jog the motor speed
- 10.07 Net Control
 - When set the Fieldbus command overrides the local control
- 10.08 Net Reference
 - When set the Fieldbus reference overrides the local reference

AC Drives for Drilling Applications

Parameter Set 11 – Reference Select

- **11.01 Keypad Ref SEL**
 - Selects the type of reference signal from the Keypad
- **11.02 EXT1/EXT2 Select**
 - Determines where the External one and two are issued from
- **11.03 EXT 1 Ref Select**
 - This sets where the external 1 reference comes from
- **11.04 EXT 1 Ref Minimum**
 - This sets the minimum value of external reference one
- **11.05 EXT 1 Ref Maximum**
 - This sets the minimum value of external reference one
- **11.06 EXT 2 Ref Select**
 - This sets where the external 2 reference comes from
- **11.07 EXT 2 Ref Minimum**
 - This sets the minimum value of external reference two
- **11.08 EXT 2 Ref Maximum**
 - This sets the minimum value of external reference two
- **11.09 EXT 1/2 Ref Select**
 - Defines the value used fro the External 1 and 2 reference
- **11.10 EXT Ref 1 PTR**
 - Defines a constant value for the External 1 Reference
- **11.11 EXT Ref 2 PTR**
 - Defines a constant value for the External 2 Reference

AC Drives for Drilling Applications

Parameter Set 12 – Constant Speeds

- **12.01 CONST SPD SEL**
 - Determines if a constant value or an external signal is used for the speed select
- **12.02 CONST Speed 1**
 - Sets the first constant speed value (0 – 18000 R.P.M.)
- **12.03 CONST Speed 2**
 - Sets the second constant speed value (0 – 18000 R.P.M.)
- **12.04 CONST Speed 3**
 - Sets the third constant speed value (0 – 18000 R.P.M.)
- **12.05 CONST Speed 4**
 - Sets the fourth constant speed value (0 – 18000 R.P.M.)
- **12.06 CONST Speed 5**
 - Sets the fifth constant speed value (0 – 18000 R.P.M.)
- **12.07 CONST Speed 6**
 - Sets the sixth constant speed value (0 – 18000 R.P.M.)
- **12.08 CONST Speed 7**
 - Sets the seventh constant speed value (0 – 18000 R.P.M.)
- **12.09 CONST Speed 8**
 - Sets the eighth constant speed value (0 – 18000 R.P.M.)
- **12.10 CONST Speed 9**
 - Sets the ninth constant speed value (0 – 18000 R.P.M.)

AC Drives for Drilling Applications

Parameter Set 12 – Constant Speed

- **12.11 CONST Speed10**
 - Sets the ten constant speed value (0 – 18000 R.P.M.)
- **12.12 CONST Speed 11**
 - Sets the eleven constant speed value (0 – 18000 R.P.M.)
- **12.13 CONST Speed 12**
 - Sets the twelve constant speed value (0 – 18000 R.P.M.)
- **12.14 CONST Speed 13**
 - Sets the thirteen constant speed value (0 – 18000 R.P.M.)
- **12.15 CONST Speed 14**
 - Sets the fourteen constant speed value (0 – 18000 R.P.M.)
- **12.16 CONST Speed 15**
 - Sets the fifteen constant speed value (0 – 18000 R.P.M.)

AC Drives for Drilling Applications

Parameter Set 13 – Analog Inputs

- **13.01 Minimum AI1**
 - Defines the minimum level of the Analog Input 1
- **13.02 Maximum AI1**
 - Defines the maximum level of the Analog Input 1
- **13.03 Scale AI1**
 - Adjust the signal by either constants or other signals to a desired level
- **13.04 Filter AI1**
 - Provides an integration time or ramp to the signal
- **13.05 Invert AI1**
 - Reverses the high and low levels of the signal, 4 mA becomes maximum speed
- **13.06 Minimum AI2**
 - Defines the minimum level of the Analog Input 2
- **13.07 Maximum AI2**
 - Defines the maximum level of the Analog Input 2
- **13.08 Scale AI2**
 - Adjust the signal by either constants or other signals to a desired level
- **13.09 Filter AI2**
 - Provides an integration time or ramp to the signal
- **13.10 Invert AI2**
 - Reverses the high and low levels of the signal, 4 mA becomes maximum speed

AC Drives for Drilling Applications

Parameter Set 13 – Analog Inputs

- **13.11 Minimum AI3**
 - Defines the minimum level of the Analog Input 3
- **13.12 Maximum AI3**
 - Defines the maximum level of the Analog Input 3
- **13.13 Scale AI3**
 - Adjust the signal by either constants or other signals to a desired level
- **13.14 Filter AI3**
 - Provides an integration time or ramp to the signal
- **13.15 Invert AI3**
 - Reverses the high and low levels of the signal, 4 mA becomes maximum speed
- **13.16 Minimum AI5**
 - Defines the minimum level of the Analog Input 5
- **13.17 Maximum AI5**
 - Defines the maximum level of the Analog Input 5
- **13.18 Scale AI5**
 - Adjust the signal by either constants or other signals to a desired level
- **13.19 Filter AI5**
 - Provides an integration time or ramp to the signal
- **13.20 Invert AI5**
 - Reverses the high and low levels of the signal, 4 mA becomes maximum speed

AC Drives for Drilling Applications

Parameter Set 13 – Analog Inputs

- **13.21 Minimum AI6**
 - Defines the minimum level of the Analog Input 6
- **13.22 Maximum AI6**
 - Defines the maximum level of the Analog Input 6
- **13.23 Scale AI6**
 - Adjust the signal by either constants or other signals to a desired level
- **13.24 Filter AI6**
 - Provides an integration time or ramp to the signal
- **13.25 Invert AI6**
 - Reverses the high and low levels of the signal, 4 mA becomes maximum speed

AC Drives for Drilling Applications

Parameter Set 14 – Relay Outputs

- **14.01 Relay RO1 Output**
 - Defines the signal that will activate Relay Output 1
- **14.02 Relay RO2 Output**
 - Defines the signal that will activate Relay Output 2
- **14.03 Relay RO3 Output**
 - Defines the signal that will activate Relay Output 3
- **14.04 RO1 TON Delay**
 - Define the on delay time for Relay 1
- **14.05 RO1 TOFF Delay**
 - Define the off delay time for Relay 1
- **14.06 RO2 TON Delay**
 - Define the on delay time for Relay 2
- **14.07 RO2 TOFF Delay**
 - Define the off delay time for Relay 2
- **14.08 RO3 TON Delay**
 - Define the on delay time for Relay 3
- **14.09 RO3 TOFF Delay**
 - Define the off delay time for Relay 3
- **14.10 DIO MOD1 RO1**
 - Defines the status of RO1 using one of the Digital Input/Output extension board

AC Drives for Drilling Applications

Parameter Set 14 – Relay Outputs

- 14.11 DIO MOD1 RO2
 - Defines the status of RO2 using one of the Digital Input/Output extension board
- 14.12 DIO MOD2 RO1
 - Defines the status of RO1 using one of the Digital Input/Output extension board
- 14.13 DIO MOD2 RO2
 - Defines the status of RO2 using one of the Digital Input/Output extension board
- 14.14 DIO MOD3 RO1
 - Defines the status of RO1 using one of the Digital Input/Output extension board
- 14.15 DIO MOD3 RO2
 - Defines the status of RO2 using one of the Digital Input/Output extension board
- 14.16 RO PTR 1
 - Defines a constant value for Relay One Output
- 14.17 RO PTR 2
 - Defines a constant value for Relay Two Output
- 14.18 RO PTR 3
 - Defines a constant value for Relay Three Output
- 14.19 RO PTR 4
 - Defines a constant value for Relay One On Delay
- 14.20 RO PTR 5
 - Defines a constant value for Relay One Off Delay

AC Drives for Drilling Applications

Parameter Set 14 – Relay Outputs

■ 14.21 RO PTR 6

- Defines a constant value for Relay Two On Delay

■ 14.22 RO PTR 7

- Defines a constant value for Relay Two Off Delay

■ 14.23 RO PTR 8

- Defines a constant value for Relay Three On Delay

■ 14.24 RO PTR 9

- Defines a constant value for Relay Three Off Delay

AC Drives for Drilling Applications

Parameter Set 15 – Analog Outputs

- **15.01 Analog Output 1**
 - Defines what signal will be Analog Output 1
- **15.02 Invert AO1**
 - Will reverse the Analog Output 1 signal, 4mA will be Maximum
- **15.03 Minimum AO1**
 - Defines lowest level of Analog Output 1
- **15.04 Filter AO1**
 - Integrates or ramps the Analog Output 1 Signal
- **15.05 Scale AO1**
 - Adjust the signal by constants to a desired level
- **15.06 Analog Output 2**
 - Defines what signal will be Analog Output 2

AC Drives for Drilling Applications

Parameter Set 15 – Analog Outputs

- **15.07 Invert AO2**
 - Will reverse the Analog Output 2 signal, 4mA will be Maximum
- **15.08 Minimum AO2**
 - Defines lowest level of Analog Output 2
- **15.09 Filter AO2**
 - Integrates or ramps the Analog Output 2 Signal
- **15.10 Scale AO2**
 - Adjust the signal by constants to a desired level
- **15.11 AO1 PTR**
 - Defines the source or constant for Analog Output 1
- **15.12 AO2 PTR**
 - Defines the source or constant for Analog Output 2

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Parameter Set 16 – System Control Inputs

- 16.01 Run Enable
 - Defines the signal that will set the Run Enable
- 16.02 Parameter Lock
 - When set the parameters can no longer be altered
- 16.03 Pass Code
 - Defines the password used to disable the Parameter Lock (358 is the initial code)
- 16.04 Fault Reset SEL
 - Resets all the system faults (only from the keypad)
- 16.05 User Macro Change
 - Allows the user to use digital inputs to change the Macro
- 16.06 Local Lock
 - Prevents the user from using local control
- 16.07 Parameter Save
 - Stores all parameters into permanent memory
- 16.08 RUN ENA PTR
 - Define the signal source for the Run Enable
- 16.09 CTRL Board Supply
 - Determines if the internal 24 VDC supply or an external one will be used

AC Drives for Drilling Applications

Parameter Set 20 – Limits

- **20.01 Minimum Speed**
 - Defines the minimum speed of the motor
- **20.02 Maximum Speed**
 - Defines the maximum speed of the motor
- **20.03 Maximum Current**
 - This is the motors maximum current
- **20.04 TORQ MAX LIM1**
 - Defines the first maximum torque of the motor
- **20.05 Overvoltage CTRL**
 - Determines if the Drive will compensate for too much DC Voltage
- **20.06 Undervoltage CTRL**
 - Determines if the Drive will compensate for too little DC Voltage
- **20.07 Minimum FREQ**
 - Defines the minimum frequency of the motor
- **20.08 Maximum FREQ**
 - Defines the maximum frequency of the motor
- **20.11 P Motoring LIM**
 - Defines the maximum power to the motor
- **20.12 P Generating LIM**
 - Defines the maximum amount of power the motor can regenerate through the inverter bridge

AC Drives for Drilling Applications

Parameter Set 20 – Limits

- **20.13 MIN TORQ SEL**
 - Defines the minimum torque delivered to the motor
- **20.14 MAX TORQ SEL**
 - Defines the maximum torque delivered to the motor
- **20.15 TORQ MIN LIM1**
 - Defines the first minimum torque of the motor
- **20.16 TORQ MIN LIM2**
 - Defines the second minimum torque of the motor
- **20.17 TORQ MAX LIM2**
 - Defines the second maximum torque of the motor
- **20.18 TORQ MIN PTR**
 - Defines the constant or signal the is the torque minimum
- **20.19 TORQ MAX PTR**
 - Defines the constant or signal the is the torque maximum
- **20.20 MIN AI1 Scale**
 - Defines the minimum level for the Analog Input one for a torque reference
- **20.21 MAX AI1 Scale**
 - Defines the maximum level for the Analog Input one for a torque reference

AC Drives for Drilling Applications

Parameter Set 21 – Start and Stop Control

- **21.01 Start Function**
 - Determines if the motor will Auto, DC Magnetize, or Constant DC Magnetize to start the motor
- **21.02 CNST MAGN Time**
 - Sets how long the magnetizing time will be needed for the motor
- **21.03 Stop Function**
 - Determines if the motor will come to a stop by ramping or coasting
- **21.04 DC Hold**
 - Determines if the DC power will be used to hold the position of the motor
- **21.05 DC Hold Speed**
 - Sets the speed for the DC Hold to use
- **21.06 DC Hold Current**
 - Sets the amount of current to the motor when in DC Hold
- **21.07 Run Enable FUNC**
 - Defines how the drive will stop when the run enable is lost
- **21.08 Scalar Fly Start**
 - Uses a flying start on the motor when in Scalar mode
- **21.09 Start INTRL FUNC**
 - Determines how the drive will stop when the Start Interlock is lost on the RMIO Board
- **21.10 Zero Speed Delay**
 - Determines how long the motor speed is at the zero speed level before setting the zero speed signal

AC Drives for Drilling Applications

Parameter Set 22 – Acceleration and Deceleration

- 22.01 ACC/DEC SEL
 - Sets the active Acceleration and Deceleration values
- 22.02 ACCEL Time 1
 - The first Acceleration Time value
- 22.03 DECEL Time 1
 - The first Deceleration Time Value
- 22.04 ACCEL Time 2
 - The second Acceleration Time value
- 22.05 DECEL Time 2
 - The second Deceleration Time Value
- 22.06 ACC/DEC Ramp SHPE
 - Sets the ramp time for the Acceleration and Deceleration values
- 22.07 EM Stop Ramp Time
 - Determines the ramp time to stop in an emergency
- 22.08 ACC PTR
 - Selects the parameter for the Acceleration/Deceleration mode
- 22.09 DEC PTR
 - Selects the parameter for the Acceleration/Deceleration mode

AC Drives for Drilling Applications

Parameter Set 23 – Speed Control

- **23.01 Gain**
 - Provides a boost to the speed controller regulator
- **23.02 Integration Time**
 - Determines how long the speed controller takes to reach user defined speed
- **23.03 Derivation Time**
 - Sets the amount of time the speed regulator uses in anticipating a speed change
- **23.04 ACC Compensation**
 - Allows the drive to smooth out the acceleration response of the motor
- **23.05 Slip Gain**
 - Compensates for the motor slip to gain a more accurate speed out of the motor
- **23.06 ACC/DEC Ramp SHPE**
 - Sets the ramp time for the Acceleration and Deceleration values
- **23.07 Autotune Run**
 - Performs a tuning function of the drive and motor for better control
 1. Set the motor speed to 20 – 40 % of rated speed
 2. Ensure load is connected to motor shaft
 3. Turn this parameter to Yes

AC Drives for Drilling Applications

Parameter Set 24 – Torque Control

- 24.01 Torque Ramp Up
 - Sets the ramp up time on the Torque Reference
- 24.02 Torque Ramp Down
 - Sets the ramp down time on the Torque Reference

AC Drives for Drilling Applications

Parameter Set 25 – Critical Speed

- **25.01 CRIT Speed Select**
 - Activate this function when there are problems running the motor at certain speeds
- **25.02 CRIT Speed 1 Low**
 - Defines the first minimum speed at which the critical speed occurs
- **25.03 CRIT Speed 1 High**
 - Defines the first maximum speed at which the critical speed occurs
- **25.04 CRIT Speed 2 Low**
 - Defines the second minimum speed at which the critical speed occurs
- **25.05 CRIT Speed 2 High**
 - Defines the second maximum speed at which the critical speed occurs
- **25.06 CRIT Speed 3 Low**
 - Defines the third minimum speed at which the critical speed occurs
- **25.07 CRIT Speed 3 High**
 - Defines the third maximum speed at which the critical speed occurs

AC Drives for Drilling Applications

Parameter Set 26 – Motor Control

- 26.01 Flux Optimization
 - Uses the flux calculation within the drive to increase performance of the motor
 - Must not have Parameter 99.04 in Scalar**
- 26.02 Flux Braking
 - Uses flux control to decrease the stopping time of the motor
- 26.03 IR Compensation
 - Determines the losses due to I^2R (Power) and adjusts the control to adjust
- 26.04 ACC Compensation
 - Allows the drive to smooth out the acceleration response of the motor
- 26.05 HEX Field Weaken
 - Determines a circular hexagonal pattern in field weakening motor
- 26.06 Flux REF PTR
 - Determines the reference used in set the Flux in the motor

AC Drives for Drilling Applications

Parameter Set 27 – Brake Chopper

- 27.01 Brake Chopper CTRL

- Activates the Brake Chopper Control of the drive

- Must have overvoltage control turned off Parameter 20.05

- 27.02 BR Overload FUNC

- Used to indicate the result if the Brake Resistors are overloaded

- 27.03 BR Resistance

- Sets the value of the Brake Resistor (0.00 to 100.00Ω)

- 27.04 BR THERM TCONST

- Defines the amount of time it takes for the Brake Resistor Heating

- 27.05 Max CONT BR Power

- Sets the maximum amount of power that the brake resistors can handle

- 27.06 BC CTRL Mode

- Determines if the brake chopper will respond to the motor when the motor acts like a generator or if the DC Bus volts gets to high

AC Drives for Drilling Applications

Parameter Set 30 – Fault Functions

- **30.01 AI<MIN Function**
 - Determines the action if the Analog Input signal is below the minimum level required
- **30.02 Panel Loss**
 - Defines the drive response when the keypad losses communications with the RDCU
- **30.03 External Fault**
 - Defines what signal will be used as an external fault from the user
- **30.04 Motor THERM PROT**
 - Determines the response from the controller when the motor overheats
- **30.05 MOT THERM P Mode**
 - Determines how the motor temperature is either measured or calculated
- **30.06 Motor THERM Time**
 - Defines a value used in one of the methods in parameter 30.05
- **30.07 Motor Load Curve**
 - With parameters 30.08 and 30.09 determines how the load on the motor during operations to help set 30.05
- **30.08 Zero Speed Load**
 - Sets the load current when the motor is at zero speed
- **30.09 Break Point**
 - The value of the load current at which point knee in the load curve
- **30.10 Stall Function**
 - Determines how the drive reacts when the motor stalls

AC Drives for Drilling Applications

Parameter Set 30 – Fault Functions

- **30.11 Stall FREQ HI**
 - defines at what frequency the Stall protection can still be used
- **30.12 Stall Time**
 - Defines how long the motor must be in a stall condition for the stall protection to occur
- **30.13 Underload FUNC**
 - Determines the reaction of the drive when the motor is in underload condition
- **30.14 Underload Time**
 - Sets the time for the motor to be in an underload condition for the Underload protection to occur
- **30.15 Underload Curve**
 - Uses the motor torque and motor frequency to determine how the motor can be underloaded
- **30.16 Motor Phase Loss**
 - Activates the motor phase loss protection
- **30.17 Earth Fault**
 - Determines if there is a warning or a fault if a ground fault occurs
- **30.18 COMM FLT FUNC**
 - Determines the drive reaction when communications is lost to the PLC
- **30.19 Main REF DS T-OUT**
 - Sets the delay on the loss of the main reference from the Master Drive in a Master Follower configuration
- **30.20 COMM FLT RO/AO**
 - Uses the Relay output and Analog Output of the communication module in the Master/Follower configuration

AC Drives for Drilling Applications

Parameter Set 30 – Fault Functions

- **30.21 AUX DS T-OUT**

- Defines the delay in the auxiliary reference in the Master/Follower configuration

- **30.22 IO CONFIG FUNC**

- Determines if there is a warning or not if the Input Output modules are incorrect

AC Drives for Drilling Applications

Parameter Set 31 – Automatic Reset

- **31.01 Number of Trials**
 - Determines how many times the drive will perform an automatic reset to get the drive running again
- **31.02 Trial Time**
 - Defines the time it takes for the automatic reset to occur
- **31.03 Delay Time**
 - Defines the time between the automatic resets
- **31.04 Overcurrent**
 - Determines the automatic reset will activate when an overcurrent occurs
- **31.05 Overvoltage**
 - Determines the automatic reset will activate when an overvoltage occurs
- **31.06 Undervoltage**
 - Determines the automatic reset will activate when an undervoltage occurs
- **31.07 AI Signal<MIN**
 - Determines the automatic reset will activate when the Analog Input signal fall below the minimum level

AC Drives for Drilling Applications

Parameter Set 32 - Supervision

- **32.01 Speed 1 Function**
 - Will activate the Speed Supervision function of the drive
- **32.02 Speed 1 Limit**
 - Defines the one of the limits of the speed supervision
- **32.03 Speed 2 Function**
 - Will activate the Speed Supervision function of the drive
- **32.04 Speed 2 Limit**
 - Defines the one of the limits of the speed supervision
- **32.05 Current Function**
 - Sets the Current Limit function of the drive
- **32.06 Current Limit**
 - Defines the value of the current limit
- **32.07 Torque 1 Function**
 - Will activate the Torque Supervision function of the drive
- **32.08 Torque 1 Limit**
 - Defines the value one of the torque limits
- **32.09 Torque 2 Function**
 - Will activate the Torque Supervision function of the drive
- **32.10 Torque 2 Limit**
 - Defines the value one of the torque limits

AC Drives for Drilling Applications

Parameter Set 32 - Supervision

- 32.11 REF 1 Function
 - Will activate the Reference Supervision function of the drive
- 32.12 REF 1 Limit
 - Defines the one of the limits of the reference one supervision
- 32.13 REF 2 Function
 - Will activate the Reference Supervision function of the drive
- 32.14 REF 2 Limit
 - Defines the one of the limits of the reference supervision
- 32.15 ACT 1 Function
 - Will activate the Active Variable Supervision function of the drive
- 32.16 ACT 1 Limit
 - Defines the one of the limits of the Active Variable supervision
- 32.17 ACT 2 Function
 - Will activate the Active Variable Supervision function of the drive
- 32.18 ACT 2 Limit
 - Defines the one of the limits of the Active Variable supervision

AC Drives for Drilling Applications

Parameter Set 33 – Software Information

■ 33.01 Software Version

- Displays the type and version of the firmware package in the controller

■ 33.02 APPL SW Version

- Displays the type and version of the application program in the controller

■ 33.03 Test Date

- Displays the test date of the system at the factory

AC Drives for Drilling Applications

Parameter Set 34 – Process Variable

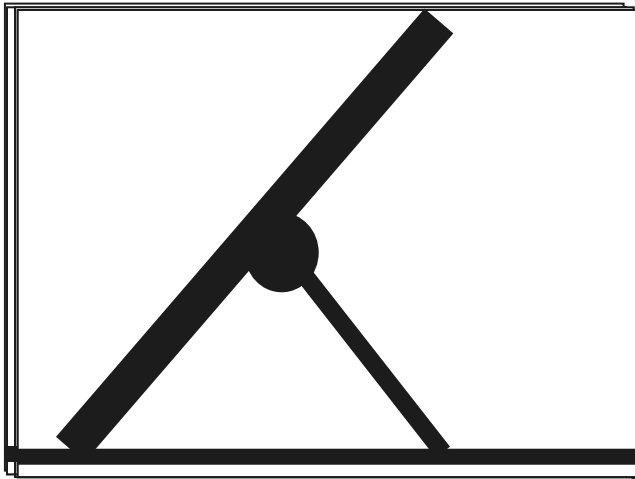
- **34.01 Scale**
 - Scales the drive variable to levels used by the user
- **34.02 P VAR Unit**
 - Defines the units used by the Process Variable
- **34.03 Select P VAR**
 - Defines the selected scaled drive variable to the Process Variable
- **34.04 Motor SP FILT TIM**
 - Defines the filter time value of the speed signal
- **34.05 TORQ ACT FILT TIM**
 - Defines the filter time value of the actual torque signal
- **34.06 Reset Run Time**
 - Resets the motor run timer

AC Drives for Drilling Applications

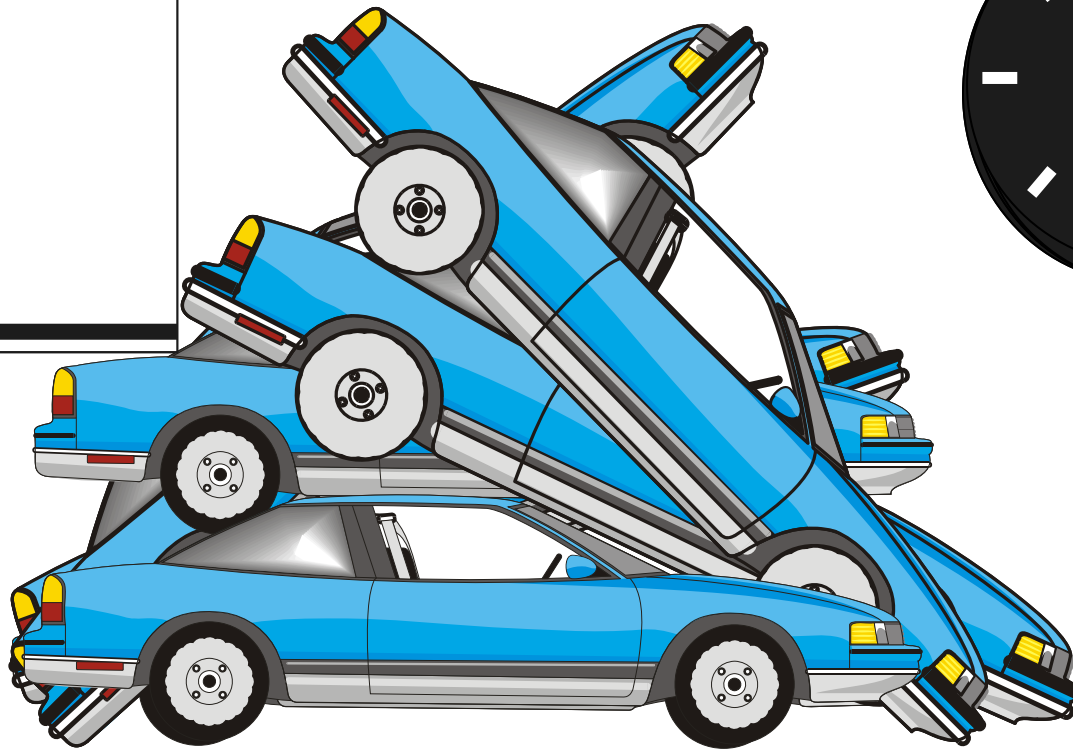
Parameter Set 35 – Motor Temperature Measure

- **35.01 MOT 1 TEMP AI1 SEL**
 - Defines which analog input will be used as the motor temperature and what type of device is used
- **35.02 MOT 1 TEMP ALM L**
 - Defines the level of the motor temperature alarm
- **35.03 MOT 1 TEMP FLT L**
 - Defines the level of the motor temperature fault
- **35.04 MOT 2 TEMP AI2 SEL**
 - Defines which analog input will be used as the motor temperature and what type of device is used
- **35.05 MOT 2 TEMP ALM L**
 - Defines the level of the motor temperature alarm
- **35.06 MOT 2 TEMP FLT L**
 - Defines the level of the motor temperature fault
- **35.07 MOT MOD COMPENSAT**
 - Determines if the Motor 1 temperature signal is used in the motor temperature compensation model

AC Drives for Drilling Applications



PID regulators



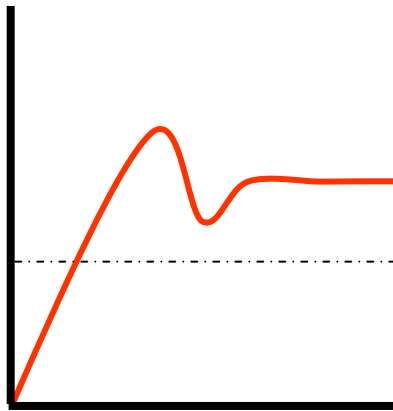
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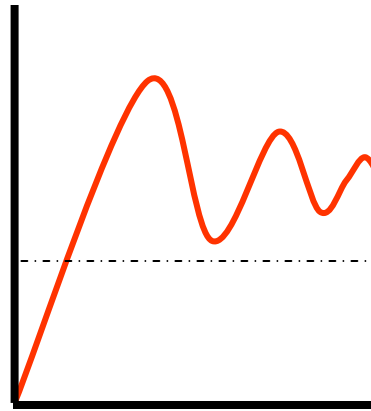
NOV NATIONAL OILWELL VARCO

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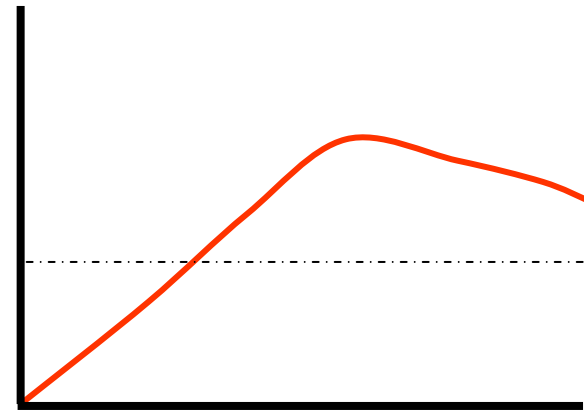
Proportional



Nominal P



Large P

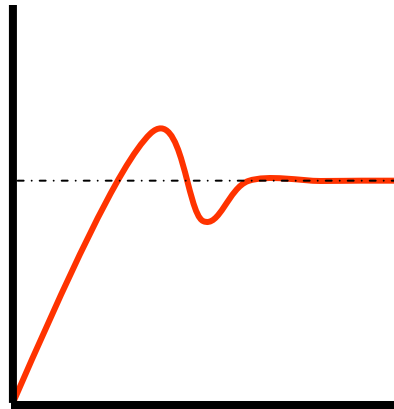


Small P

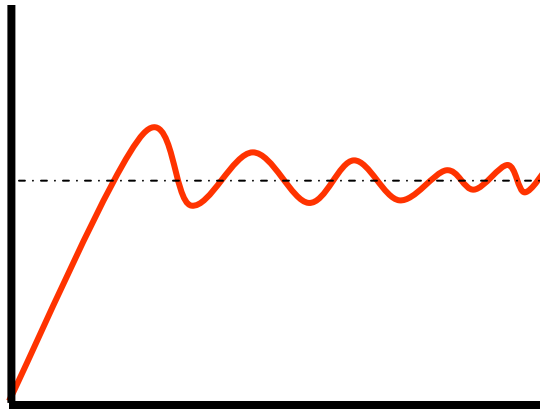
$$\text{Proportional} = P_{\text{gain}} * \text{Error (Ref/Fdbk)}$$

AC Drives for Drilling Applications

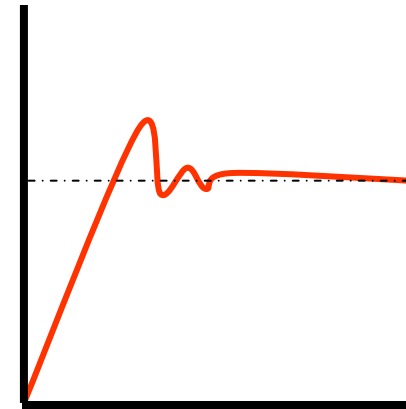
Integral



Nominal I



Small I

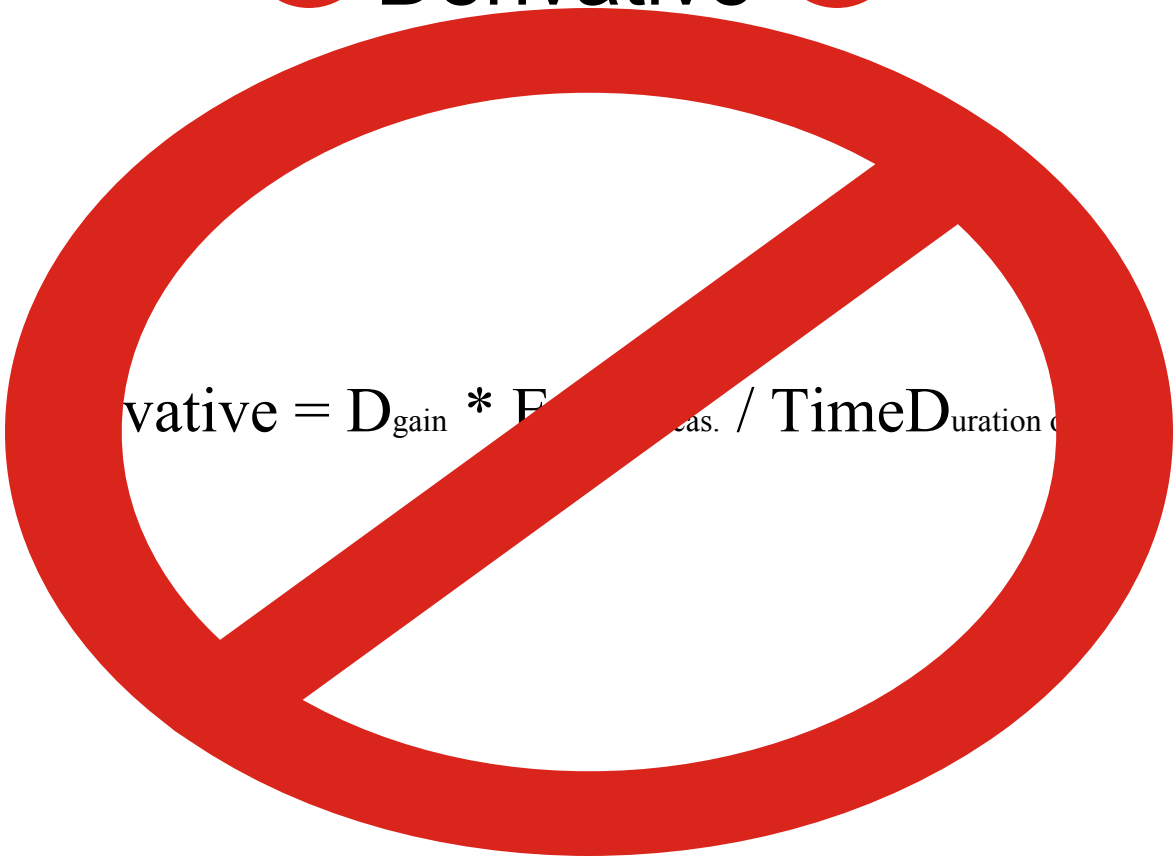


Large I

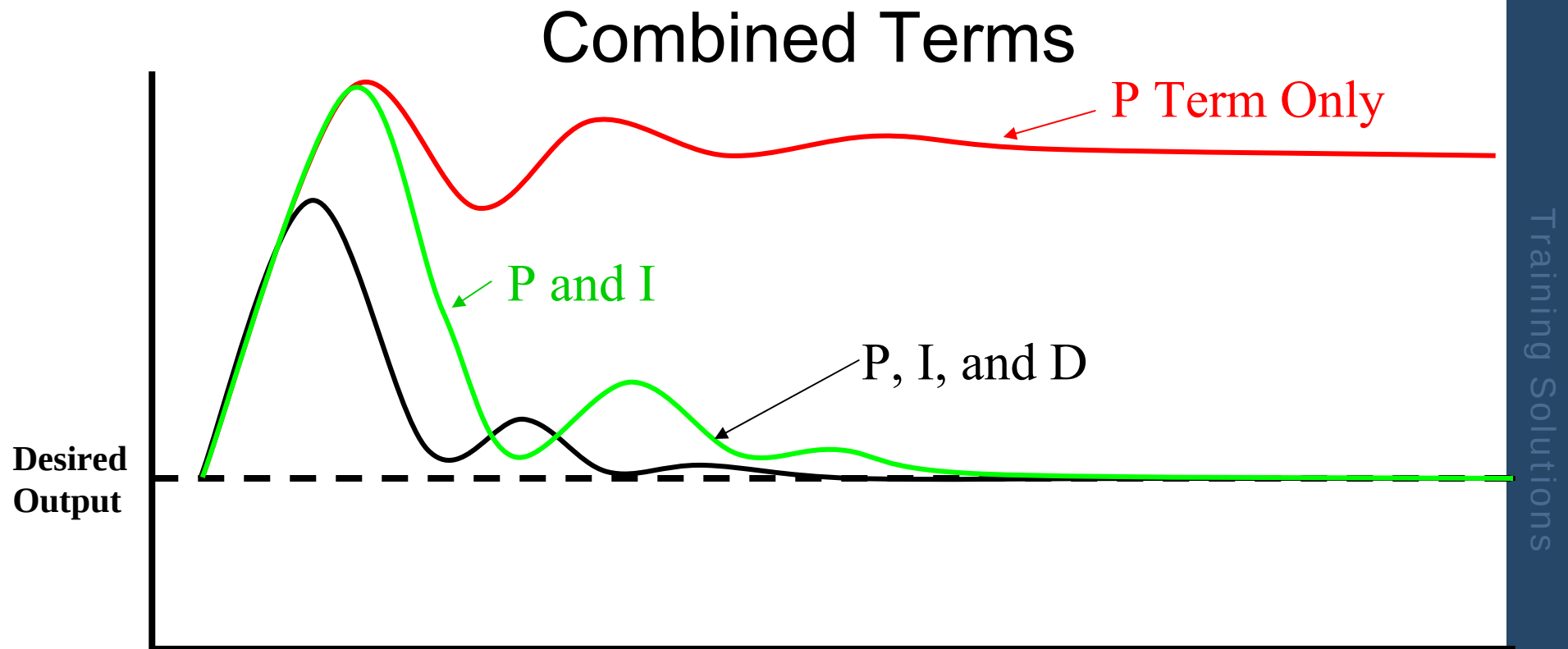
$$\text{Integral} = I_{\text{gain}} * \text{Error}_{\text{AVG/Time}} * \text{Time of AVG}$$

AC Drives for Drilling Applications

 Derivative 

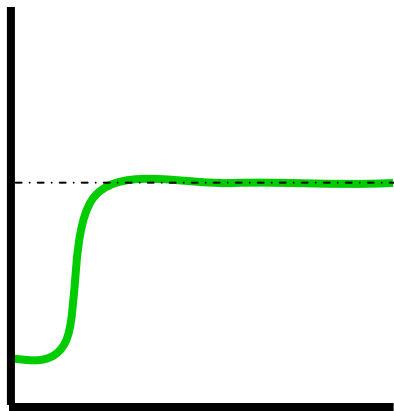

Derivative = $D_{\text{gain}} * F_{\text{meas.}} / \text{TimeDuration}$

AC Drives for Drilling Applications

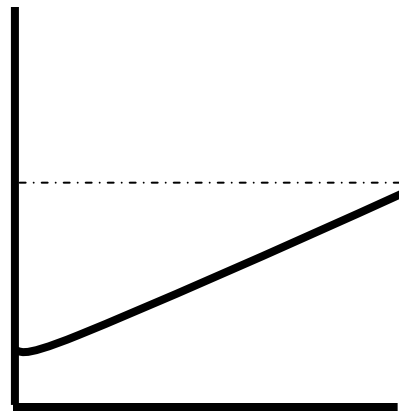


AC Drives for Drilling Applications

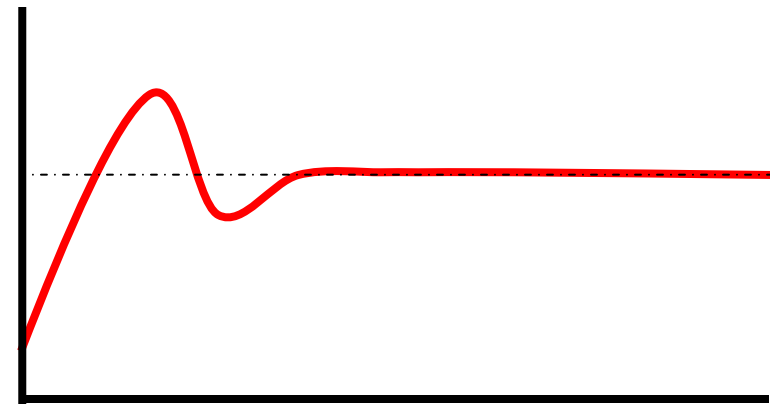
Desired Output Signal



Reference
Input



Feedback
Input



Desired Output

AC Drives for Drilling Applications

Parameter Set 40 – PID Control

- **40.01 Gain**
 - This is the Proportional constant (k_p) used in the regulator
- **40.02 PID INTEG Time**
 - This is the Integral constant (k_i) used in the regulator
- **40.03 PID DERIV Tim**
 - This is the Derivative constant (k_d) used in the regulator
- **40.04 PID DERIV Filter**
 - Defines a time value added to the (k_d) to smooth out the response
- **40.05 Error Value INV**
 - Inverts the error of the Input and feedback signals of the PID regulator
- **40.06 Actual Value SEL**
 - Selects the process actual value used in the PID regulator
- **40.07 Actual 1 Input SEL**
 - Determines which signal will be used as the first actual input
- **40.08 Actual 2 Input SEL**
 - Determines which signal will be used as the second actual input
- **40.09 ACT 1 Minimum**
 - Sets the lowest level allowed for the first actual input
- **40.10 ACT 1 Maximum**
 - Sets the highest level allowed for the first actual input

AC Drives for Drilling Applications

Parameter Set 40 – PID Control

- **40.11 ACT 2 Minimum**
 - Sets the lowest level allowed for the second actual input
- **40.12 ACT 2 Maximum**
 - Sets the highest level allowed for the second actual input
- **40.13 PID Integration**
 - This activates the Integral constant (k_i) used in the regulator
- **40.14 Trim Mode**
 - Defines how the PID regulator adjust for differences feedback signals
- **40.15 Trim REF SEL**
 - Defines the analog signal used for the trim function
- **40.16 Trim Reference**
 - Defines a constant for the trim reference if selected by parameter 40.15
- **40.17 Trim Range Adjust**
 - Defines a gain applied to the output of the PID regulator for trimming
- **40.18 Trim Select**
 - Determines whether the trim function will be applied to the speed or torque reference
- **40.19 Actual FILT Time**
 - Sets the time constant for filter the signal that is the input to the PID regulator
- **40.20 Sleep Selection**
 - Determines the signal used to activate the PID regulator sleep function

AC Drives for Drilling Applications

Parameter Set 40 – PID Control

- **40.21 Sleep Level**
 - Defines the level of the motor speed for the sleep function to activate
- **40.22 Sleep Delay**
 - Defines the amount time before the sleep function activates
- **40.23 Wake Up Level**
 - This is defines the motor speed level for the PID regulator activates
- **40.24 Wake Up Delay**
 - Defines the amount time before the sleep function to deactivates
- **40.25 ACT 1 PTR**
 - Defines the constant value used for the Actual Value processed by the PID regulator
- **40.26 PID Minimum**
 - Defines the minimum level for the PID output
- **40.27 PID Maximum**
 - Defines the maximum level for the PID output

AC Drives for Drilling Applications

Brake Chopper – ABB



AC Drives for Drilling Applications

Brake Chopper – Powerex



AC Drives for Drilling Applications

Brake Chopper – Vacon



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Braking

- Similar to Dynamic Braking
 - Motor is converted to a Generator
 - The output is rectified
 - The regenerated current is consumed by a resistor
 - Typical Impedance of 0.8Ω
 - Continuity should be verified at Start Up
 - The Current is “Chopped” through the resistor
 - The DC Link Voltage is monitored

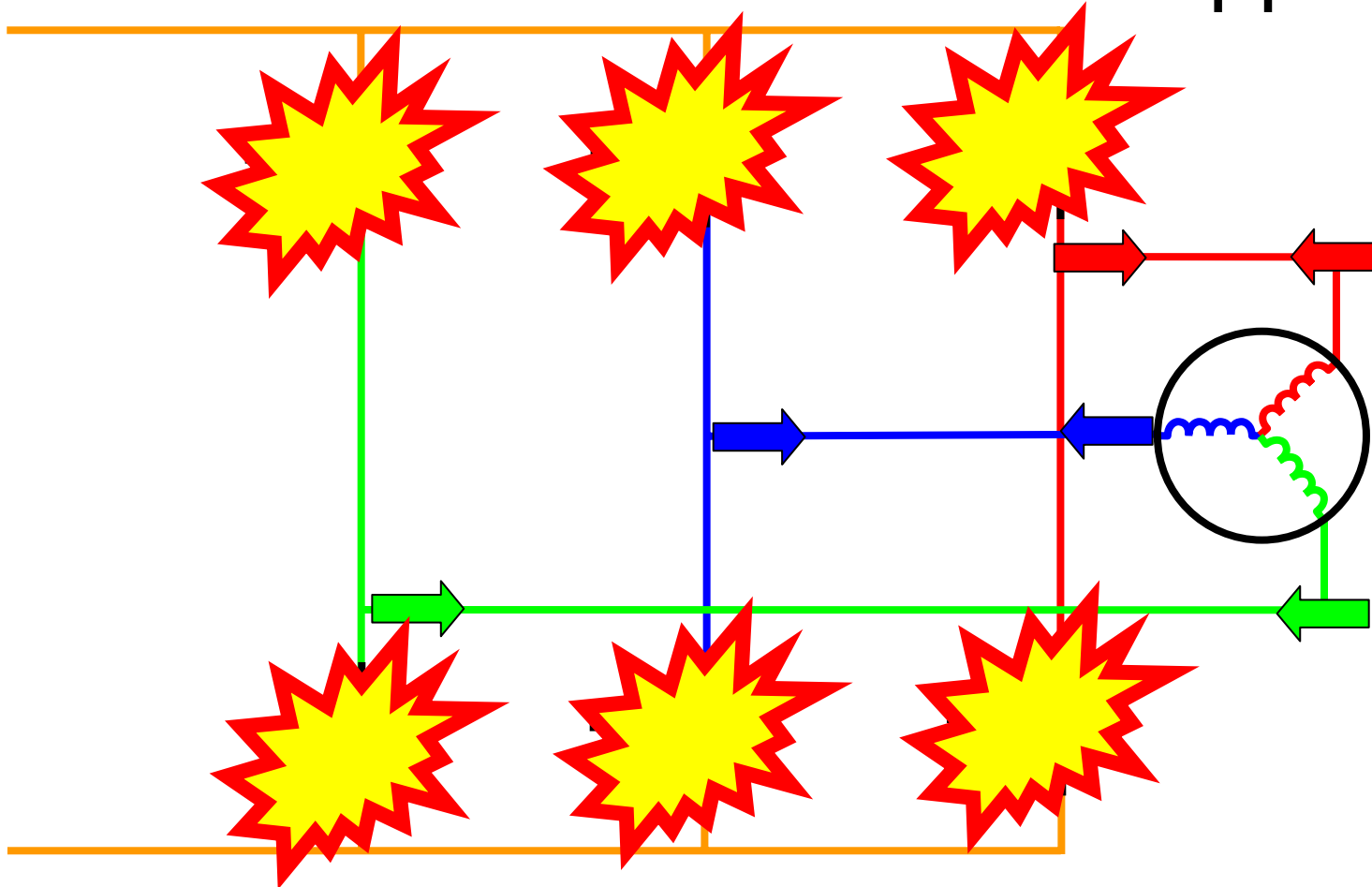
AC Drives for Drilling Applications

Brake Chopper

- An additional Phase Cell is required
 - The Phase Cell is called the Brake Chopper
 - Configured the same as the individual Phase Cells in the Inverter Bridge
 - Only Difference is in the Controller (ASIC Board)
 - The resistor is series with the Brake Chopper
 - The Brake Chopper and Resistor is in Parallel with the Inverter Bridge
 - Other Device can be used to Brake the Physical Motor

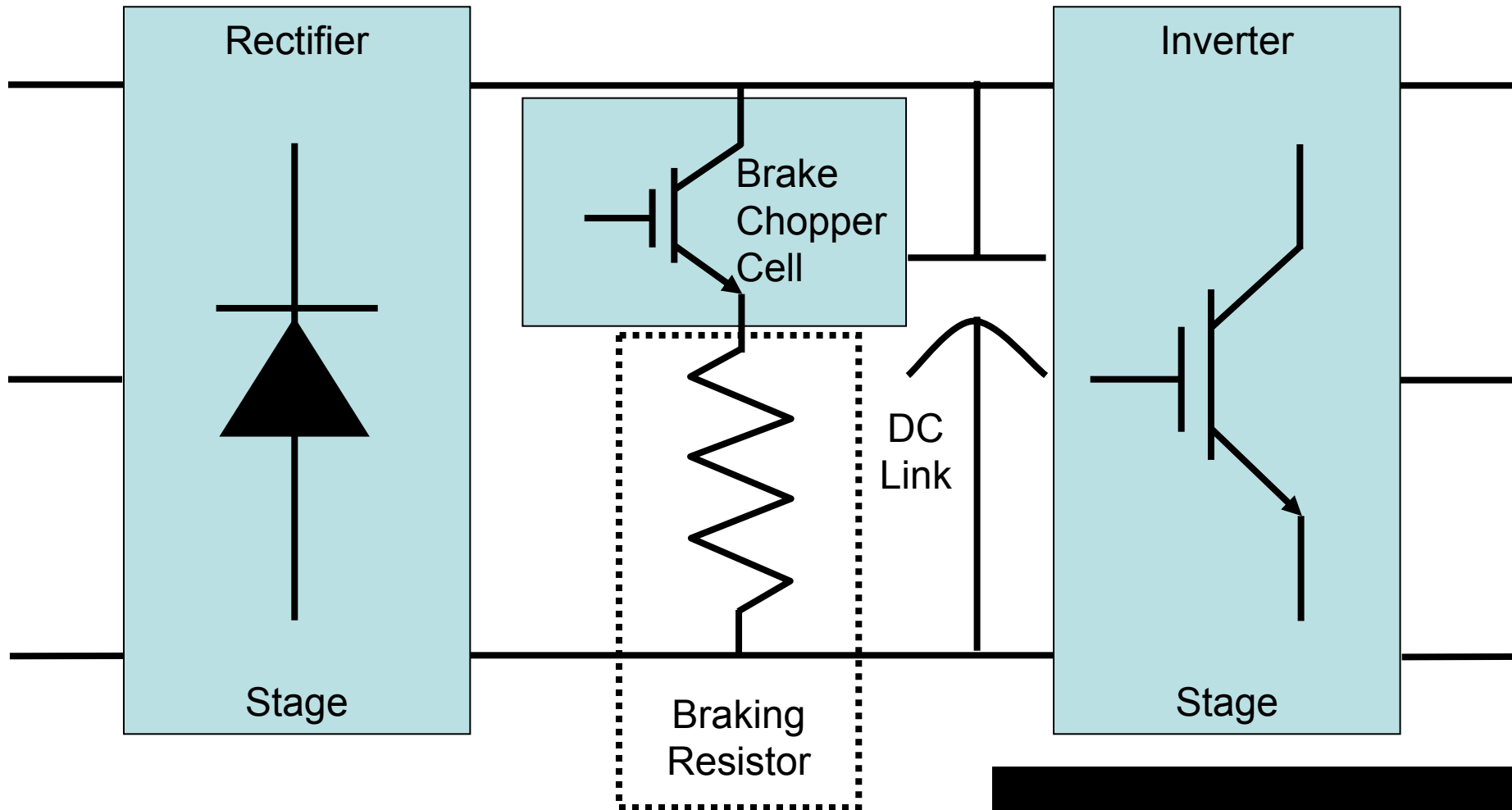
AC Drives for Drilling Applications

The Need for Brake Choppers



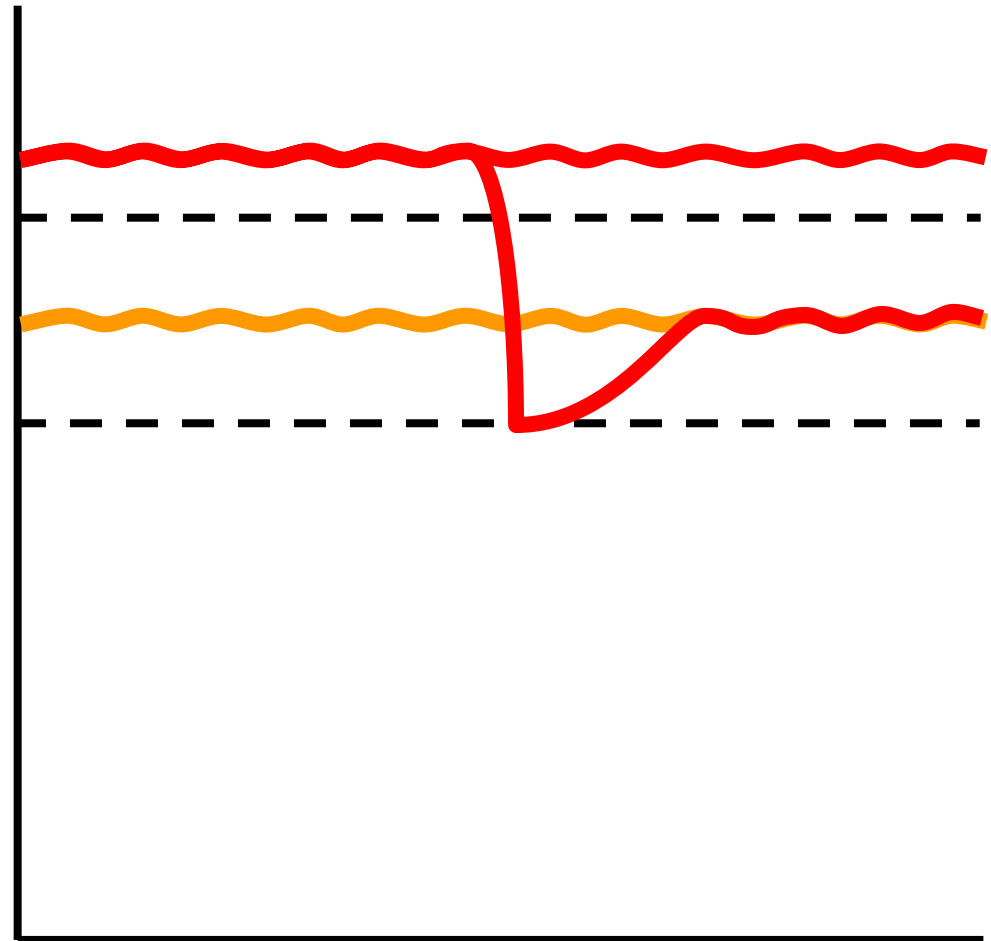
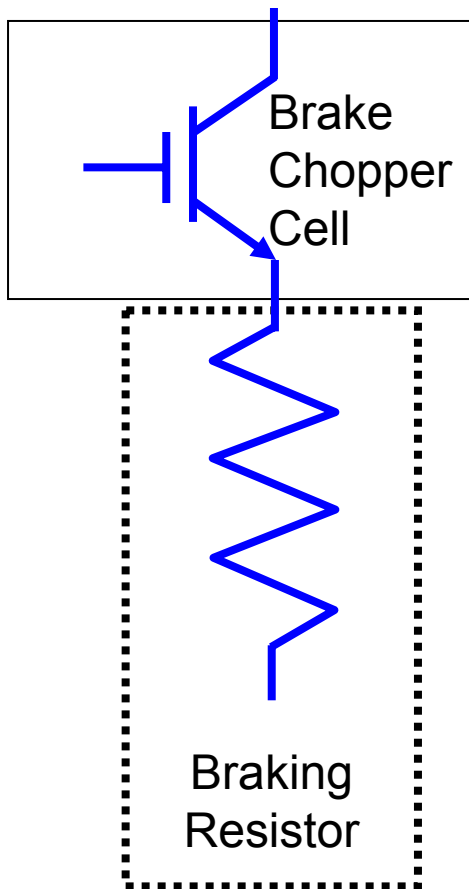
AC Drives for Drilling Applications

Brake Chopper location in the AC Drive



AC Drives for Drilling Applications

Brake Chopper Function



AC Drives for Drilling Applications

Brake Chopper Resistors - Water Cooled



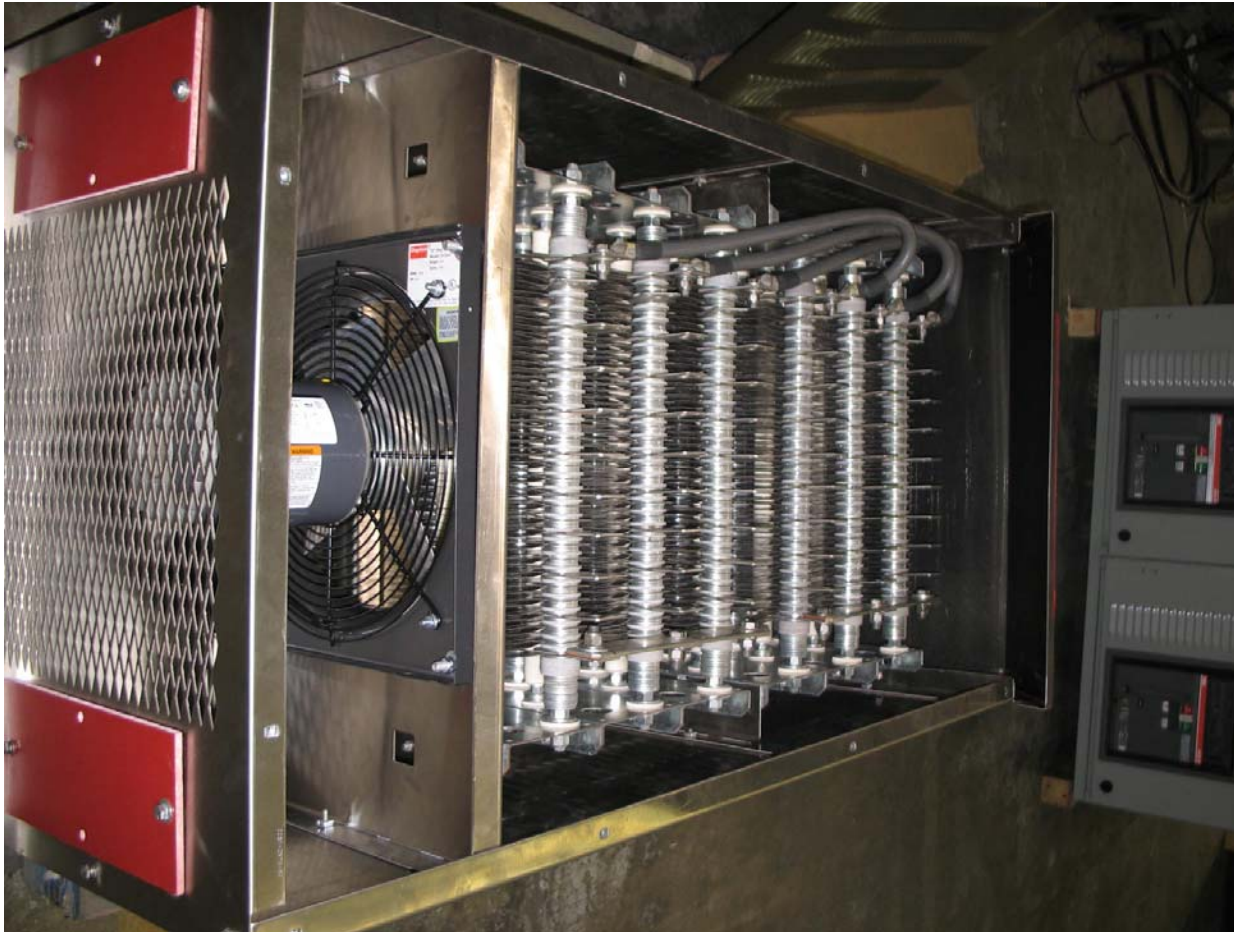
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AC Drives for Drilling Applications

Brake Chopper Resistors - Air Cooled



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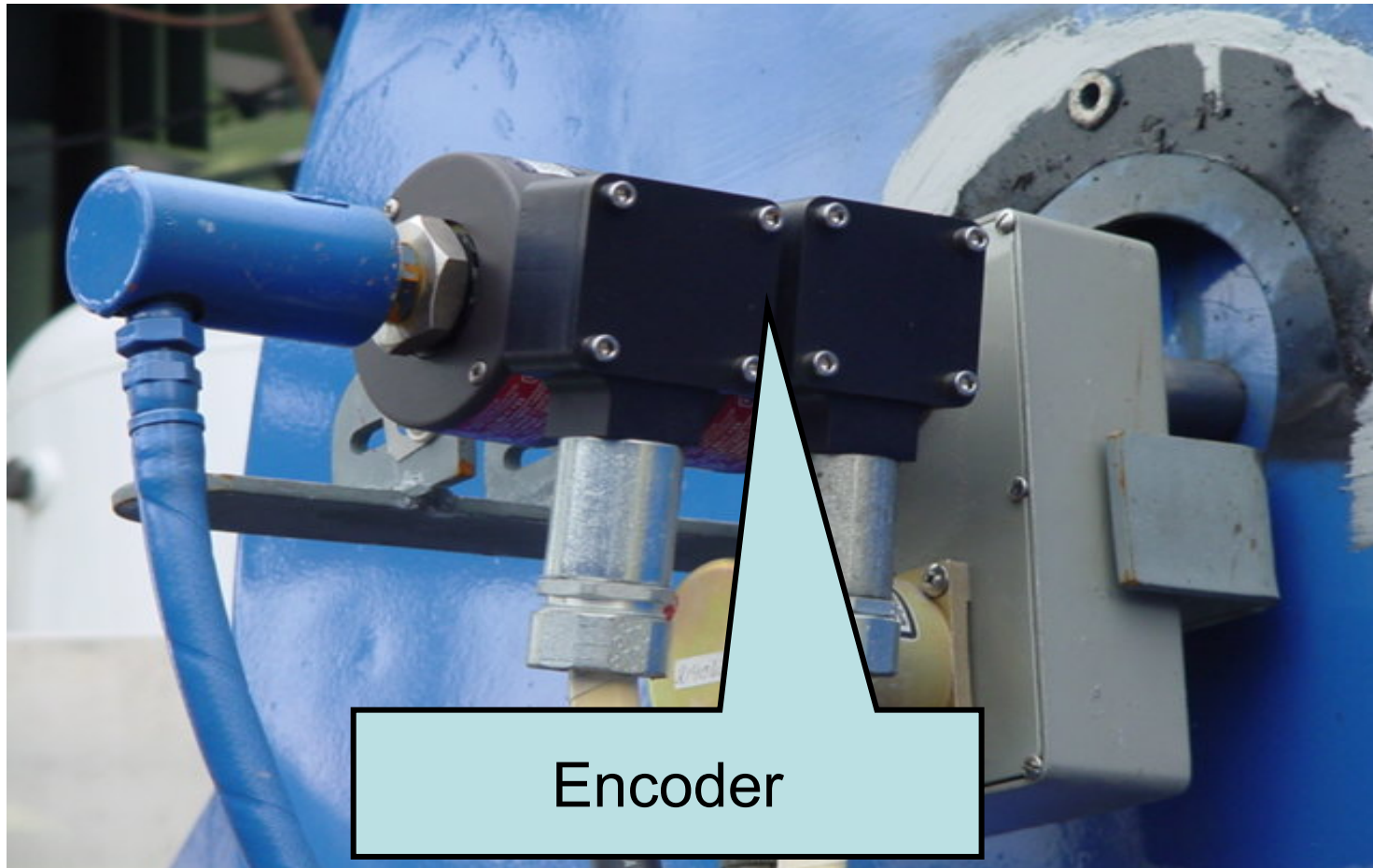
NOV NATIONAL OILWELL VARCO

AC Drives for Drilling Applications

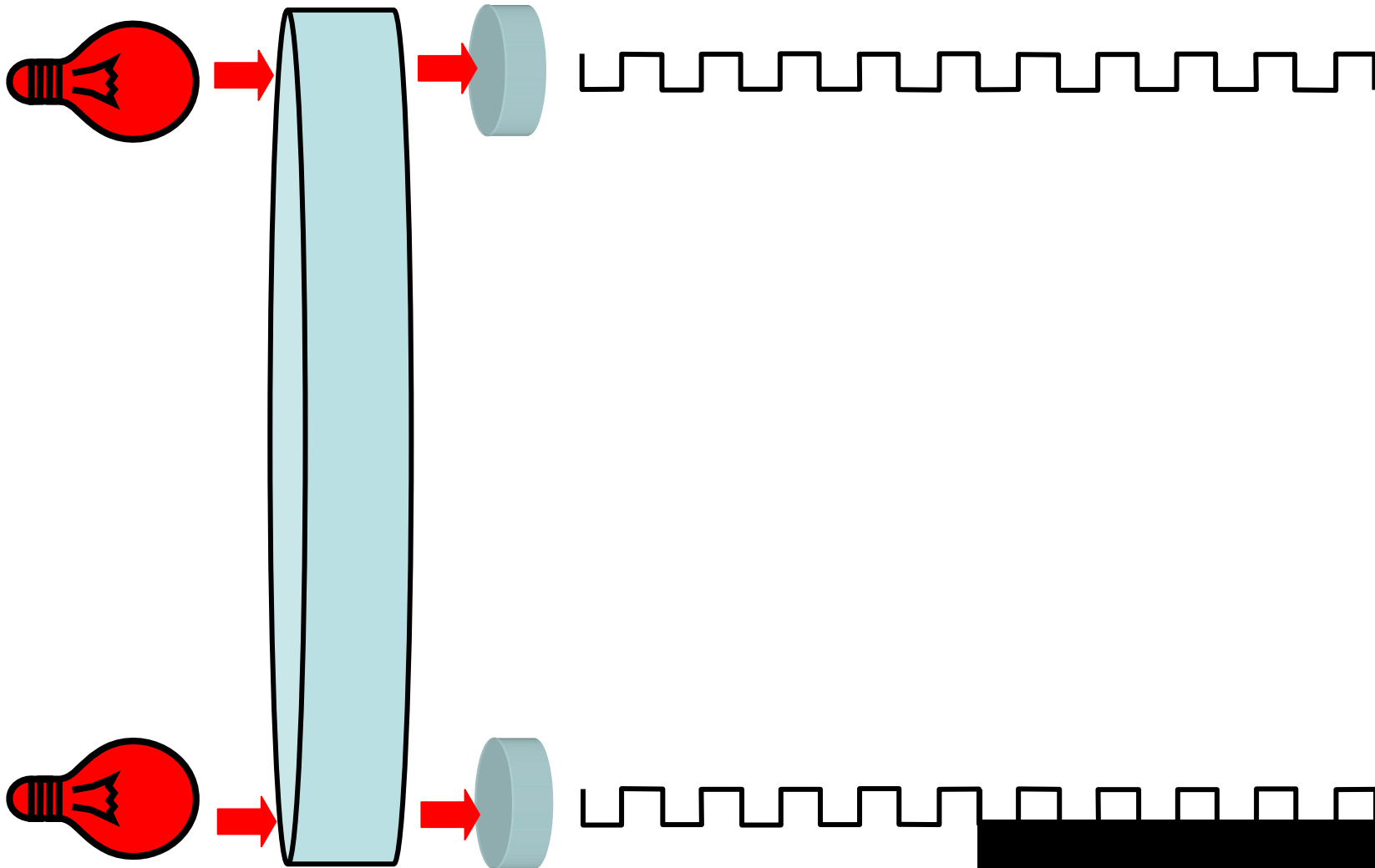
Parameter Set 42 – Brake Control

- **42.01 Brake CTRL**
 - This will activate the brake control function
- **42.02 Brake Acknowledge**
 - Determines where the brake on off supervision
- **42.03 Brake Open Delay**
 - This sets the time delay between the brake on and the speed control release
- **42.04 Brake Close Delay**
 - This sets the time delay between the brake release and the speed control
- **42.05 ABS Brake CLS SPD**
 - Defines the speed of the motor in which the brake is closed
- **42.06 Brake Fault FUNC**
 - Defines the reaction of the drive with a brake failure
- **42.07 Start TORQ REF SEL**
 - Defines the signal that is the Starting Torque reference
- **42.08 Start TORQ REF**
 - Determines the constant the will be the torque applied to the motor to start
- **42.09 Extend Run T**
 - Defines the time allowed to extend the brake control function to run
- **42.10 Lowest BRK Hold**
 - Defines the lowest speed reference for the brake to hold the motor

AC Drives for Drilling Applications



AC Drives for Drilling Applications



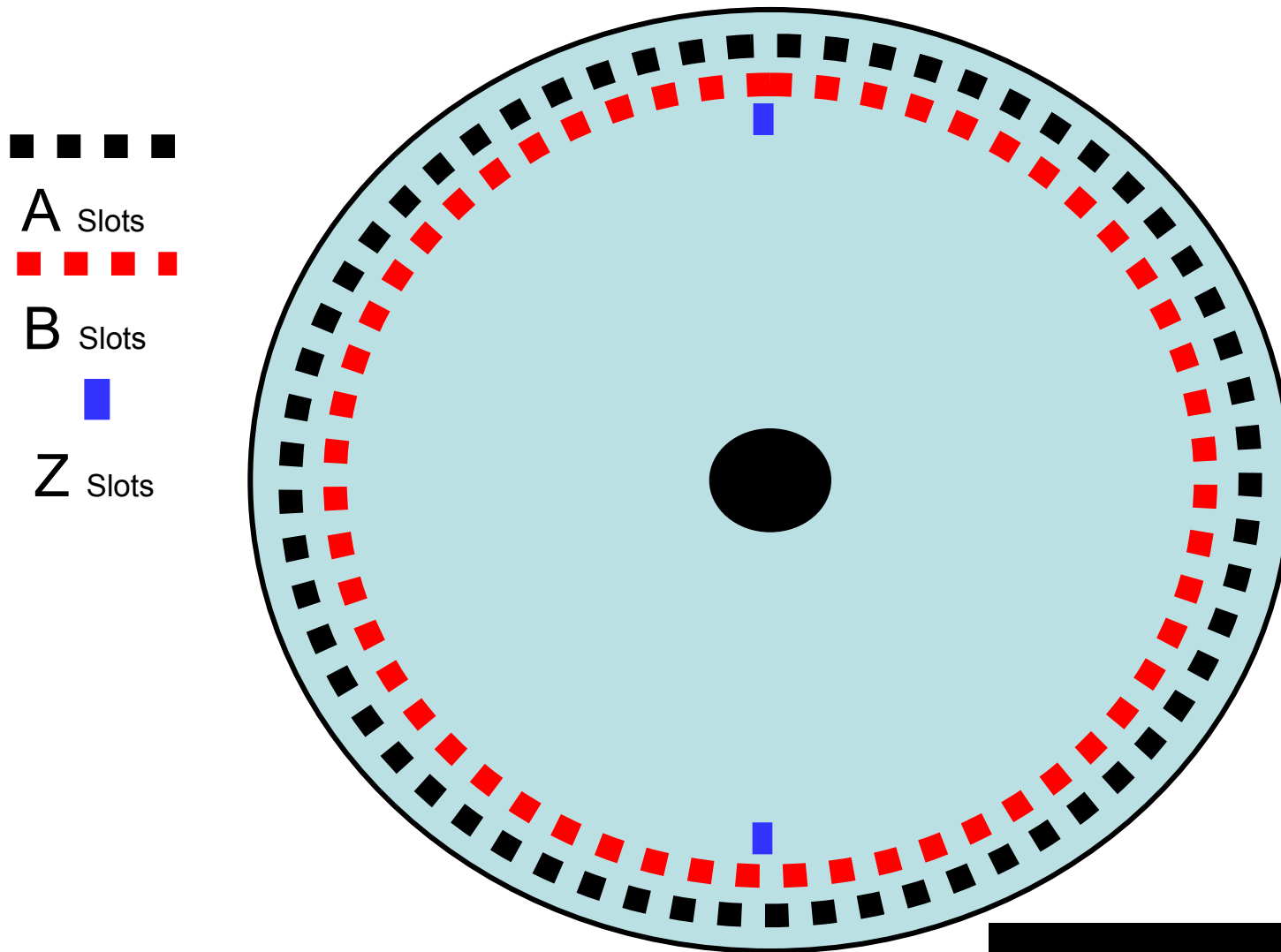
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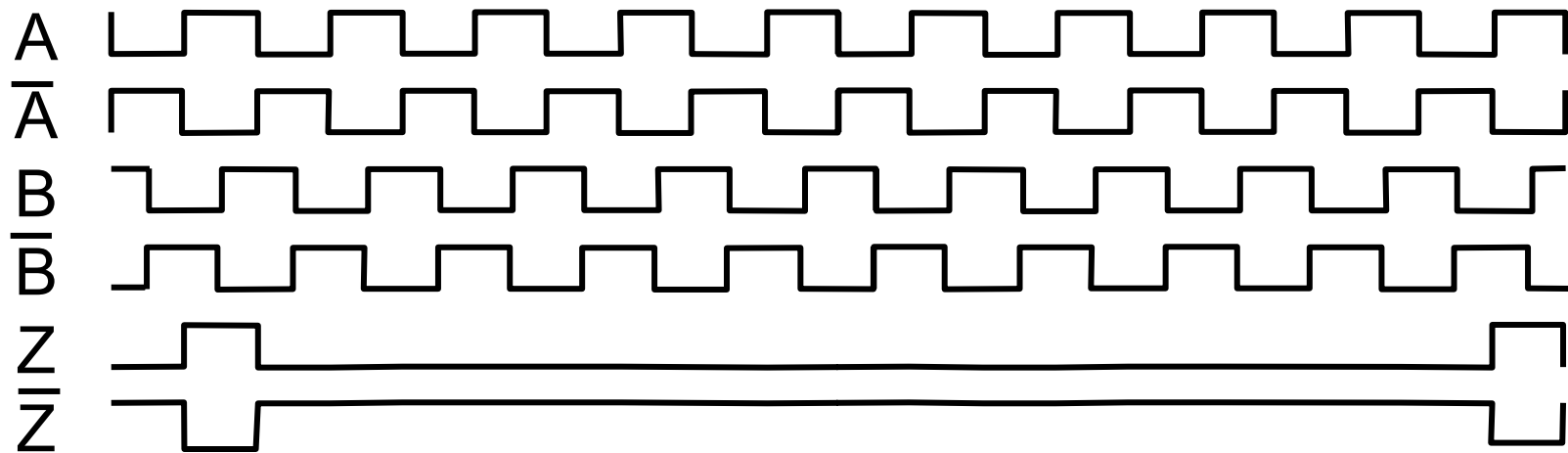


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AC Drives for Drilling Applications



AC Drives for Drilling Applications



A Leads B by 90° A
 $\bar{A}$ Leads $\bar{B}$ by 90° A
Leads A $\bar{B}$ by 180° B
Leads B $\bar{B}$ by 180°

Z is the Index signal It
occurs once per revolution
Z Leads $\bar{Z}$ by 180°

AC Drives for Drilling Applications

Parameter Set 50 – Encoder Module

- **50.01 Pulse NR**
 - Sets the number of pulses per revolution
- **50.02 Speed MEAS Mode**
 - Defines how the encoder pulses will be measured
- **50.03 Encoder Fault**
 - Determines the drive reaction when there is a fault with the encoder
- **50.04 Encoder Delay**
 - Defines the delay for the encoder supervision
- **50.05 Encoder DDCS Chanel**
 - Defines the fiber optic channel that the encoder data will be relayed through
- **50.06 Speed FB SEL**
 - Defines which speed feedback signal will be used for control

AC Drives for Drilling Applications

Communications Board – Parameters

■ Baud Rate

- Sets the speed of the data exchanged between the ABB Drive and the System PLC
- The PLC baud rate must match the Drive baud rate
- There are 10 Rates as follow;
- 10 = Auto
- 9 = 12 Mega-bauds
- 8 = 6 Mega-bauds
- 7 = 3 Mega-bauds
- 6 = 1.5 Mega-bauds
- 5 = 500 Kilo-bauds
- 4 = 187.5 Kilo-bauds
- 3 = 93.75 Kilo-bauds
- 2 = 19.2 Kilo-bauds
- 1 = 9.6 Kilo-bauds

AC Drives for Drilling Applications

Communications Board – Parameters

- PPO Type (Profibus/PrOcess Data Type)
 - Five types of PPO (PPO1-5)
 - PPO Type determines the size of data exchanges (Byte groups)
 - There three sections to the Parameter Field
 - A. Parameter Type and Index = Two Bytes
 - B. Parameter Sub-index = Two Bytes
 - C. Parameter Field = Four Bytes
 - Process Data Field has two categories
 - A. Master to Slave
 - B. Slave to Master
 - C. Maximum Size is 20 Bytes (20 Bytes = PPO 5)

AC Drives for Drilling Applications

Communications Board – Parameters

■ Operating Mode

- Fieldbus

- A. PLC protocol, typically Profibus DP in NOV systems.
- B. Other PLC protocol can be used such as Device net, Control net, Modbus, Canbus, etc...

- ABB Drives

- A. ABB standard protocol developed for their product lines.
- B. Designed to talk to their Drive systems, PLC, HMI, etc...

- Generic

- A. Programmable for other Protocol that are not standardized.
- B. Will be setup by engineers, is not used by NOV.

AC Drives for Drilling Applications

Communications Board – Parameters

■ Profibus Monitoring

- Parameter Group 3

- A. All values displayed in hexadecimal format, Drive Windows 2.20 will allow number format change.
- B. Main Control words and Fault words are displayed
- C. The auxiliary words (Fault, Status, and Limit) are determined by Parameter group 51 and the PLC Program.
- D. All PLC data can be viewed in the Monitor and Data logger function of the DriveWindows Program.
- E. When viewing the values using the Keypad they will only be displayed in Hexadecimal format.

AC Drives for Drilling Applications

Communications Board – Parameters

■ Network addresses

- Each device on the network has a unique ID number
- No two devices can have the same address
- The drive's default address is 126
- Addresses can range from 2 to 126
- Verify the address of the drive to the Hardware Configuration File of the PLC program

AC Drives for Drilling Applications

Parameter Set 51 – Communications Module Data

- **51.01 Module Type**
 - This will determine the type of Fieldbus communications protocol – PROFIBUS DP
- **51.02 Node Address**
 - Determines the address of the AC Drive on the Network
- **51.03 Baud Rate**
 - This sets the communications rate of the network – 1500 (1.5mbps)
- **51.04 PPO Type**
 - This sets the PPO Type (will be discussed later) of the network - 5
- **51.05 PZD3 Out**
 - Defines the third word from the PLC to the Drive - 3
- **51.06 PZD3 In**
 - Defines the third word from the Drive to the PLC - 313
- **51.07 PZD4 Out**
 - Defines the fourth word from the PLC to the Drive - 2004
- **51.08 PZD4 In**
 - Defines the fourth word from the Drive to the PLC - 104
- **51.09 PZD5 Out**
 - Defines the fifth word from the PLC to the Drive - 2015
- **51.10 PZD5 In**
 - Defines the fifth word from the Drive to the PLC - 105

AC Drives for Drilling Applications

Parameter Set 51 – Communications Module Data

- **51.11 PZD6 Out**
 - Defines the sixth word from the PLC to the Drive - 2011
- **51.12 PZD6 In**
 - Defines the sixth word from the Drive to the PLC - 106
- **51.13 PZD7 Out**
 - Defines the seventh word from the PLC to the Drive - 6001
- **51.14 PZD7 In**
 - Defines the seventh word from the Drive to the PLC - 107
- **51.15 PZD8 Out**
 - Defines the eighth word from the PLC to the Drive - 8501
- **51.16 PZD8 In**
 - Defines the eighth word from the Drive to the PLC - 8504
- **51.17 PZD9 Out**
 - Defines the ninth word from the PLC to the Drive - 8504
- **51.18 PZD9 In**
 - Defines the ninth word from the Drive to the PLC- 305
- **51.19 PZD10 Out**
 - Defines the tenth word from the PLC to the Drive - 0
- **51.20 PZD10 In**
 - Defines the tenth word from the Drive to the PLC - 306

AC Drives for Drilling Applications

Parameter Set 51 – Communications Module Data

- **51.21 DP Mode**
 - Determines if the mode is DP or DPV1
- **51.22 FIELDBUS PAR 22**
 - Read Protected, cannot be viewed
- **51.23 FIELDBUS PAR 23**
 - Read Protected, cannot be viewed
- **51.24 FIELDBUS PAR 24**
 - Read Protected, cannot be viewed
- **51.25 FIELDBUS PAR 25**
 - Read Protected, cannot be viewed
- **51.26 FIELDBUS PAR 26**
 - Read Protected, cannot be viewed
- **51.27 FB PAR Refresh**
 - Determines if the Parameters are loaded or need to be refreshed
- **51.28 FILE CPI FW REF**
 - Defines if the Drive is in Forward or Reverse, Hexadecimal Display
- **51.29 FILE CONFIG ID**
 - File Configuration ID for communications
- **51.30 FILE CONFIG REV**
 - File Configuration Revision number

AC Drives for Drilling Applications

Parameter Set 51 – Communications Module Data

- **51.31 FBA Status**

- Tells if the Fieldbus is online or not

- **51.32 FILE CPI FW REV**

- Fieldbus firmware revision number

- **51.33 FILE APPL FW REV**

- Fieldbus Application firmware revision number

AC Drives for Drilling Applications

Parameter Set 52 – Standard Modbus

- **52.01 Station Number**

- This sets the number of the drive for Modbus network

- **52.02 Baud Rate**

- Defines the rate of data transfer rate on the network

- **52.03 Parity**

- Defines the use of stop and parity bits

AC Drives for Drilling Applications

Parameter Set 60 – Master/Follower

- **60.01 Master Link Mode**
 - Sets the drive for a Master Follower configuration
- **60.02 Torque Selector**
 - Selects the reference used for the follower control
- **60.03 Window SEL ON**
 - When used with the ADD function it acts as a speed supervision for torque controlled drives
- **60.04 Window Width On**
 - On Time Supervision width of the window used for the speed control
- **60.05 Window Width Off**
 - Off Time Supervision width of the window used for the speed control
- **60.06 Droop Rate**
 - Places a reduction in control on the Follower drive
- **60.07 Master Signal 2**
 - Selects a signal to be sent to the Follower drive
- **60.08 Master Signal 3**
 - Selects a signal to be sent to the Follower drive

AC Drives for Drilling Applications

Parameter Set 70 – Master/Follower

- **70.01 Channel 0 ADDR**
 - Defines the node address for the first fiber optic port
- **70.02 Channel 3 ADDR**
 - Defines the node address for the fourth fiber optic port
- **70.03 CH1 Baudrate**
 - Defines the data transfer rate for the second fiber optic port
- **70.04 CH0 DDCS HW CONN**
 - Defines whether the Channel 0 network is in a Star or Ring

AC Drives for Drilling Applications

Parameter Set 83 – Adaptive Program Control

- **83.01 ADAPT PROG CMD**
 - Runs, Edits, or Stops the adaptive program
- **83.02 Edit Command**
 - Makes changes to the Adaptive program block element
- **83.03 Edit Block**
 - Defines the block location number to be edited
- **83.04 Time Level Set**
 - Determines the cycle time of the Adaptive Program
- **83.05 Passcode**
 - Defines the password to protect the adaptive program

AC Drives for Drilling Applications

Parameter Set 84 – Adaptive Program

- **84.01 Status**
 - Nine bits to represent the status of the Adaptive Program
- **84.02 Faulted PAR**
 - Indicates the parameter in the Adaptive Program
- **84.05 Block 1**
 - Sets the function of the Block (ABS, ADD, AND, COMPARE, EVENT, MAX, MIN, MULDIV, NO, OR, PI, PI-BAL, SR, SWITCH-B, SWITCH-I, TOFF, TON, TRIGG, and XOR)
- **84.06 Input 1**
 - First signal into the block
- **84.07 Input 2**
 - Second signal into the block
- **84.08 Input 3**
 - Third signal into the block
- **84.09 Output**
 - Store the output in the first Block Parameter Set
- **84.79 Output**
 - Store the output in the fifteenth Block Parameter Set

AC Drives for Drilling Applications

Parameter Set 85 – User Constants

- **85.01 Constant 1**
 - Sets the first constant of the adaptive program
- **85.02 Constant 2**
 - Sets the second constant of the adaptive program
- **85.03 Constant 3**
 - Sets the third constant of the adaptive program
- **85.04 Constant 4**
 - Sets the fourth constant of the adaptive program
- **85.05 Constant 5**
 - Sets the fifth constant of the adaptive program
- **85.06 Constant 6**
 - Sets the sixth constant of the adaptive program
- **85.07 Constant 7**
 - Sets the seventh constant of the adaptive program
- **85.08 Constant 8**
 - Sets the eighth constant of the adaptive program
- **85.09 Constant 9**
 - Sets the ninth constant of the adaptive program
- **85.10 Constant 10**
 - Sets the tenth constant of the adaptive program

AC Drives for Drilling Applications

Parameter Set 85 – User Constants

- **85.11 String 1**
 - Stores a message to be used by the adaptive program
- **85.12 String 2**
 - Stores a message to be used by the adaptive program
- **85.13 String 3**
 - Stores a message to be used by the adaptive program
- **85.14 String 4**
 - Stores a message to be used by the adaptive program
- **85.15 String 5**
 - Stores a message to be used by the adaptive program

AC Drives for Drilling Applications

Parameter Set 90 – Data Set Received Addresses

- **90.01 AUX DS REF 3**
 - Determines the third reference signal from the fieldbus
- **90.02 AUX DS REF 4**
 - Determines the fourth reference signal from the fieldbus
- **90.03 AUX DS REF 5**
 - Determines the fifth reference signal from the fieldbus
- **90.04 Main DS Source**
 - Defines the location of the Control Word, Reference 1, and Reference 2 from the fieldbus
- **90.05 AUX DS Source**
 - Defines the location of the Reference 3, and Reference 4, and Reference 5 from the fieldbus

AC Drives for Drilling Applications

Parameter Set 92 – Data Set Transmit and Received Addresses

- **92.01 Main DS Status Word**
 - Loads the Status word to the fieldbus
- **92.02 Main DS ACT 1**
 - Stores the first actual value to the fieldbus
- **92.03 Main DS ACT 2**
 - Stores the second actual value to the fieldbus
- **92.04 Main DS ACT 3**
 - Stores the third actual value to the fieldbus
- **92.05 Main DS ACT 4**
 - Stores the fourth actual value to the fieldbus
- **92.06 Main DS ACT 5**
 - Stores the fifth actual value to the fieldbus

AC Drives for Drilling Applications

Parameter Set 96 – External Analog Outputs

- **96.01 EXT AO 1**
 - Defines the signal to be sent out on Analog Output 1
- **96.02 Invert EXT AO 1**
 - Inverts the signal going out on Analog Output 1
- **96.03 Minimum EXT AO 1**
 - Defines the lowest level of the first Analog Output
- **96.04 Filter EXT AO 1**
 - A time constant is entered to filter the first Analog Output 1
- **96.05 Scale EXT AO1**
 - Adjusts the first Analog Output for the user
- **96.06 EXT AO 2**
 - Defines the signal to be sent out on Analog Output 2
- **96.07 Invert EXT AO 2**
 - Inverts the signal going out on Analog Output 2
- **96.08 Minimum EXT AO 2**
 - Defines the lowest level of the second Analog Output
- **96.09 Filter EXT AO 2**
 - A time constant is entered to filter the first Analog Output 2
- **96.10 Scale EXT AO 2**
 - Adjusts the second Analog Output for the user

AC Drives for Drilling Applications

Parameter Set 96 – External Analog Outputs

- **96.11 EXT AO 1 PTR**

- Defines the constant to be sent out on Analog Output 1

- **96.12 EXT AO 2 PTR**

- Inverts the constant going out on Analog Output 1

AC Drives for Drilling Applications

Upload

Steps To Perform Upload

- Set up drive as desired
- Push keypad “Func” key
- Use “Double Arrow” keys to select upload, download
- Use “Single Arrow” keys to select “Upload” (blinking curser)
- Push “Enter” button on keypad
- Process complete

Steps To Perform Application Download

- Ensure keypad is in the “Local” mode
- Ensure drive to be programmed is in same Macro (factory default)
- Enter motor data into 99 group and option data in 98 group if required
- Perform motor ID run
- Push keypad “Func” key
- Use “Double Arrow” keys to select “Download” (blinking curser)
- Push “Enter” button on keypad
- Process complete

AC Drives for Drilling Applications

Upload

Download With Motor Data

- Place keypad on drive to be download to and put keypad into “Local” mode
- In 99 group, select language and 98 group, select options if required
- Press “PAR” key and using double arrow keys, go to 16 group, then use single arrow keys, select parameter 16.03
- Press “Enter” and using arrow keys, enter pass code (564), then press “Enter” key
- Press “Func” key, use double arrow keys to select upload/download, use single arrow keys to select download
- Press enter
- After download is completed, turn power off for 10 seconds, then back on
- Process complete

AC Drives for Drilling Applications

Drive Interface Software

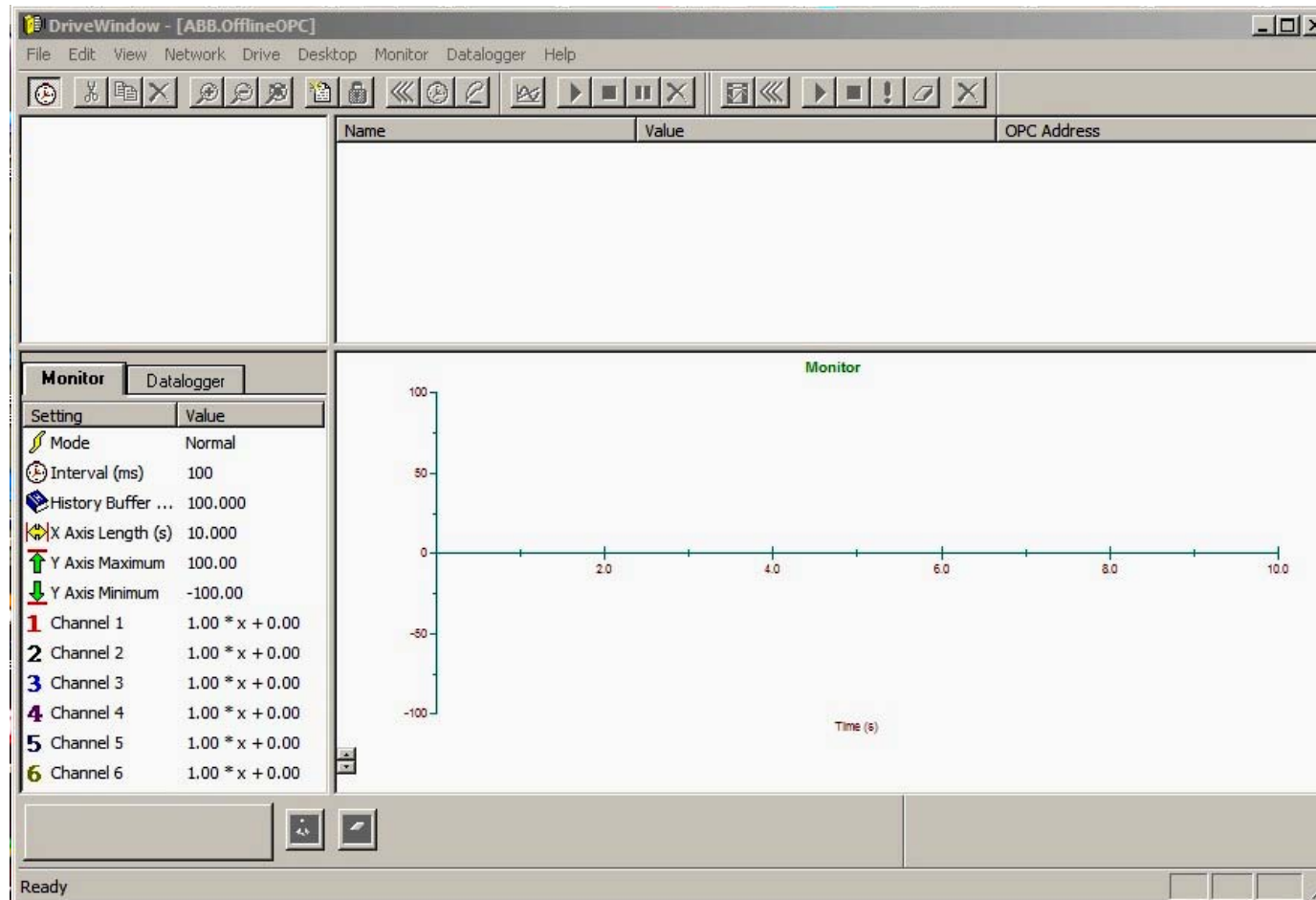
DriveWindows Lite

- Online monitoring of the AC Drive
- Can Change Parameters
- Historical graphing of the drive signals
- Can connect to multiple drives

*Only one drives' parameters can be viewed

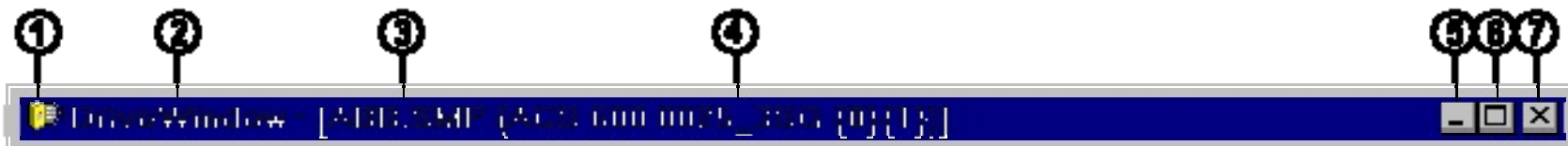
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DriveWindows



AC Drives for Drilling Applications

DriveWindows – Title Bar



The title bar is located along the top of a window. It consists of the following parts:

1. System menu button
2. Application name (DriveWindow)
3. Network (OPC) server and remote location
4. Name of the drive or [open parameter file](#) currently selected in the [browse tree pane](#)
5. Minimize button, same as Minimize in the [System menu](#). Reduces the window to an icon
6. Maximize/restore button (depends on current maximize status of the window), same as Maximize or Restore in the [System menu](#).
7. Close button, same as Close in the [System menu](#).

AC Drives for Drilling Applications

DriveWindows – Menu Commands

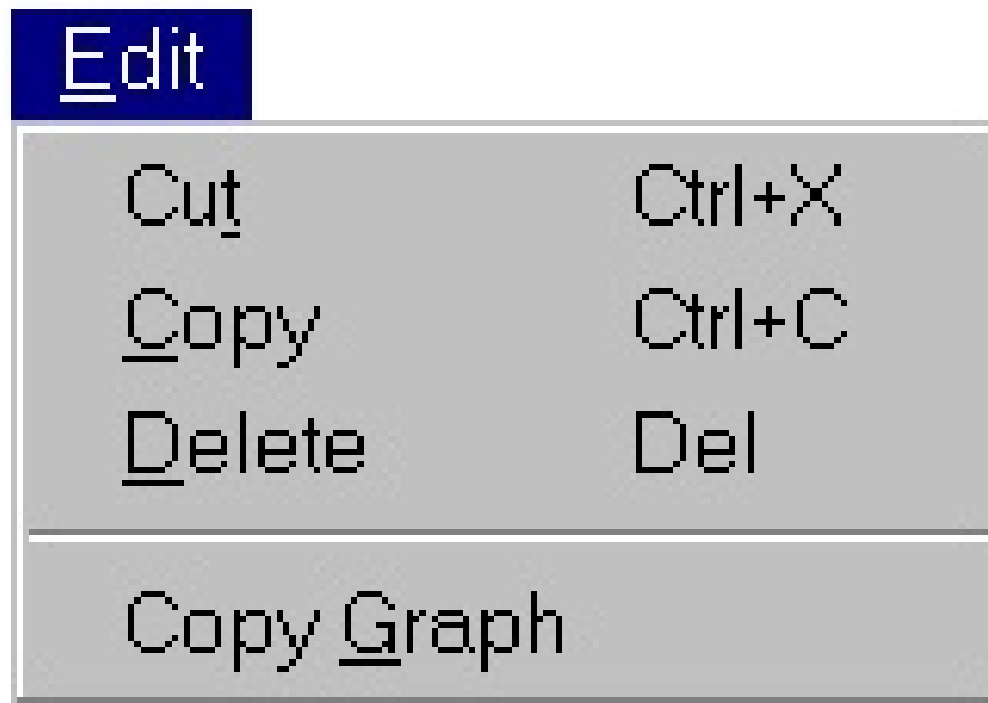
File Menu



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DriveWindows – Menu Commands

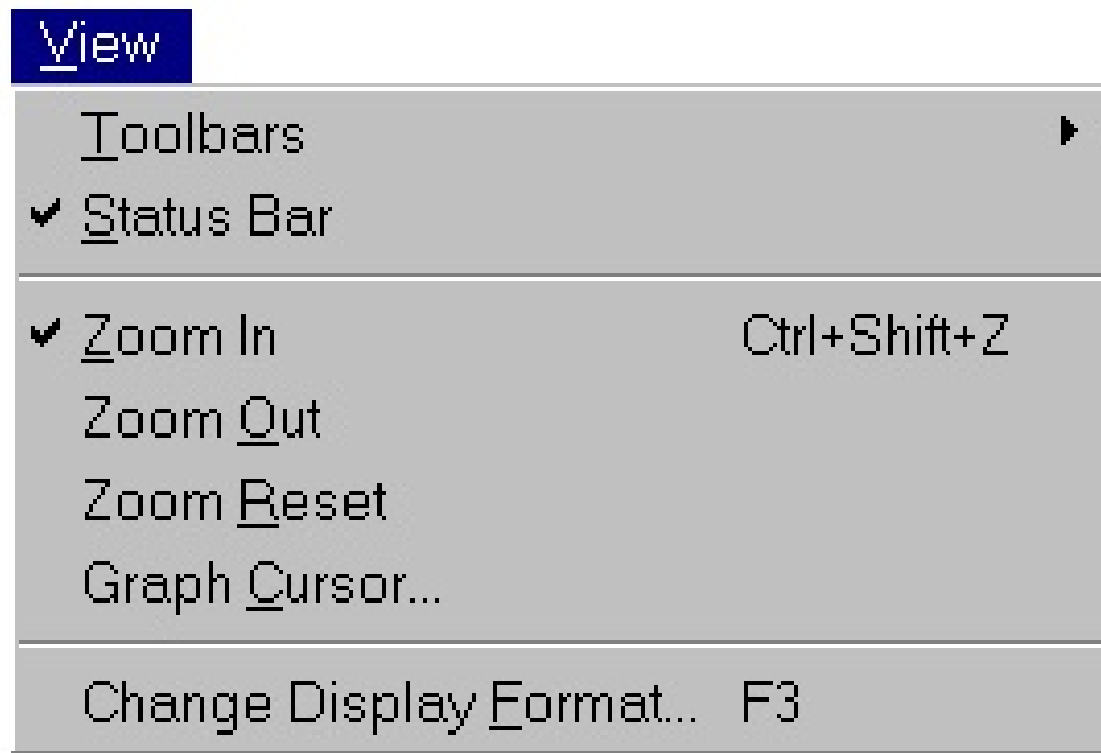
Edit Menu



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DriveWindows – Menu Commands

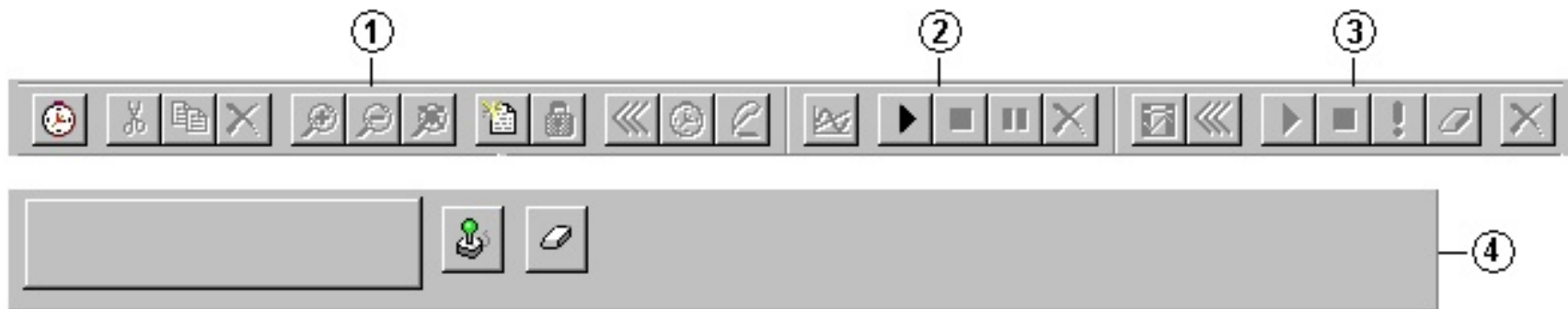
View Menu



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DriveWindows – Menu Commands

View Menu - Toolbars



The toolbars provide quick mouse access to many tools used in DriveWindow. DriveWindow has the following toolbars:

1. [Standard toolbar](#)
2. [Monitor toolbar](#)
3. [Logger toolbar](#)
4. [Drive panel toolbar](#)

AC Drives for Drilling Applications

DriveWindows – Menu Commands

Network Menu



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DriveWindows – Menu Commands

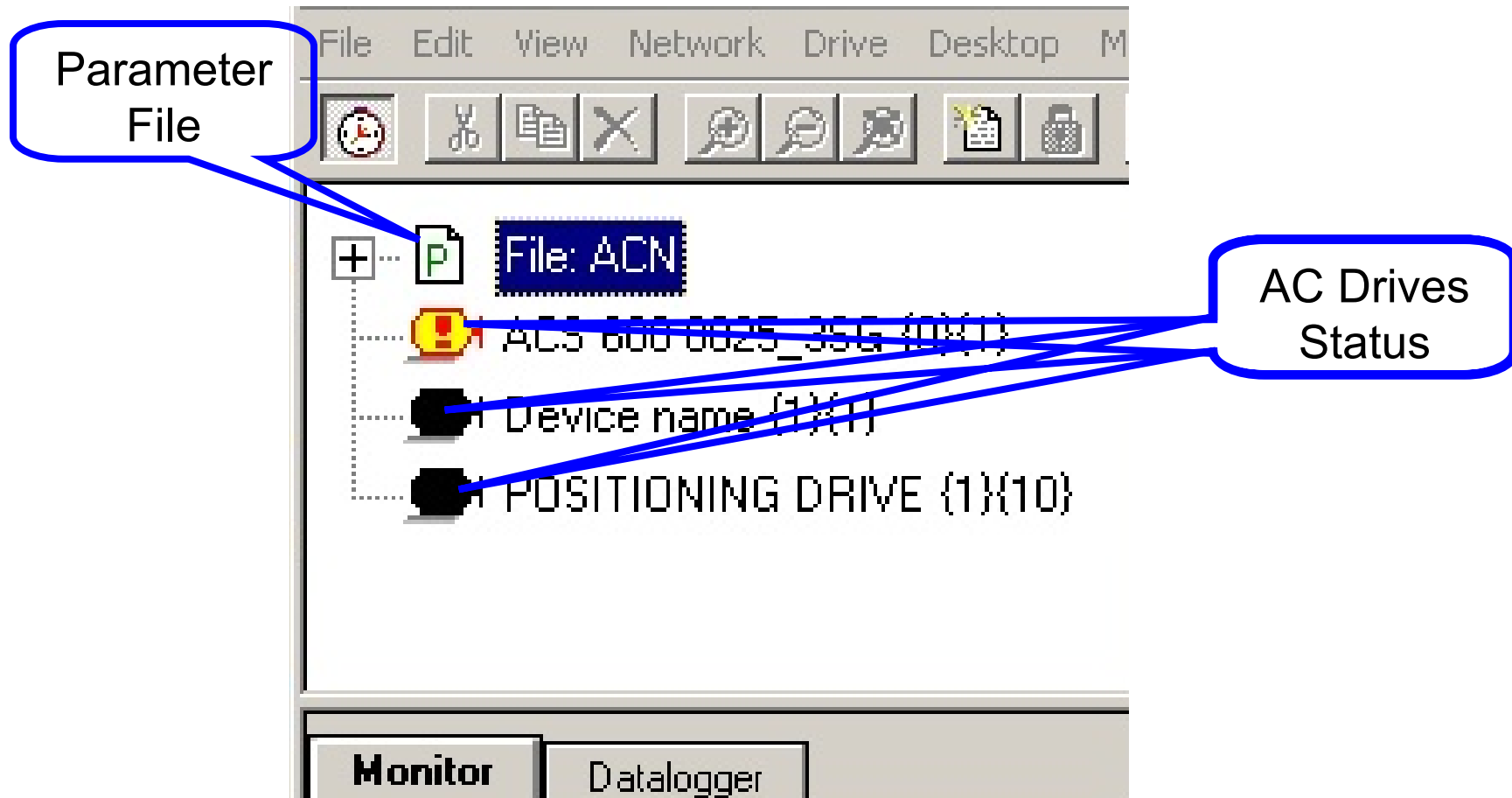
Drive Menu

Drive	
Take <u>C</u> ontrol	Alt+F2
C <u>l</u> ear Faultlogger	
R <u>e</u> set Fault	Alt+F8
<u>S</u> tart	Shift+F9
S <u>t</u> op	Shift+F10
<u>R</u> everse	Ctrl+F5
<u>F</u> orward	Ctrl+F6
C <u>o</u> ast Stop	Ctrl+F4
Step Settings...	
Step <u>S</u> tart	

Drive	
Release <u>C</u> ontrol	Alt+F2
C <u>l</u> ear Faultlogger	
R <u>e</u> set Fault	Alt+F8
<u>S</u> tart	Shift+F9
S <u>t</u> op	Shift+F10
<u>R</u> everse	Ctrl+F5
<u>F</u> orward	Ctrl+F6
C <u>o</u> ast Stop	Ctrl+F4
Step Settings...	
Step <u>S</u> tart	

AC Drives for Drilling Applications

Drive Windows – Tree Pane



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DriveWindows – Tree Pane Drive Status

Image Status

	Fault and (Forward) Direction
	Fault and not (Forward) Direction
	Not Running and Warning and (Forward) Direction
	Not Running and Warning and not (Forward) Direction
	Not Running and (Forward) Direction
	Not Running and not (Forward) Direction
	Running and Warning and (Forward) Direction
	Running and Warning and not (Forward) Direction
	Running and (Forward) Direction
	Running and not (Forward) Direction
	Otherwise (status display is off-line or status cannot be read, for example)

AC Drives for Drilling Applications

DriveWindows – Menu Commands

Desktop Menu



AC Drives for Drilling Applications

DriveWindows – Menu Commands

Monitor Menu



Monitor	
Setting	Value
 Mode	Normal
 Interval (ms)	100
 History Buffer (s)	100.000
 X Axis Length (s)	10.000
 Y Axis Maximum	100.00
 Y Axis Minimum	-100.00
1 Channel 1	1.00 * x + 0.00
2 Channel 2	1.00 * x + 0.00
3 Channel 3	1.00 * x + 0.00
4 Channel 4	1.00 * x + 0.00
5 Channel 5	1.00 * x + 0.00
6 Channel 6	1.00 * x + 0.00

Drive Windows – Monitor

Monitor settings consist of the following:

- Mode, same as Fast Mode toggle in the [Monitor menu](#). Double-clicking the name of the setting [toggles](#) between fast and normal [mode](#) of monitoring.
- Interval, same as Interval command in the [Monitor menu](#). Double-clicking the name of the setting presents an Interval dialog box, where you can change the monitoring [interval](#).
- History Buffer, same as History Buffer command in the [Monitor menu](#). Double-clicking the name of the setting presents a History Buffer dialog box, where you can change the size of the monitor [history buffer](#), i.e., how much data is remembered by the monitor.
- X Axis Length, same as X Length command in the [Axis submenu](#) of the [Monitor menu](#). Double-clicking the name of the setting presents an X Axis Length dialog box, where you can change the [x-axis length](#) of the monitor graph at current zooming level, if any.
- Y Axis Maximum, same as Y Axis Maximum command in the [Axis submenu](#) of the [Monitor menu](#). Double-clicking the name of the setting presents a Y Axis Maximum dialog box, where you can change the [y-axis maximum](#) value of the monitor graph at current zooming level, if any.
- Y Axis Minimum, same as Y Axis Minimum command in the [Axis submenu](#) of the [Monitor menu](#). Double-clicking the name of the setting presents a Y Axis Minimum dialog box, where you can change the [y-axis minimum](#) value of the monitor graph at current zooming level, if any.
- Channel 1, ... Channel 6, same as Channel 1, ... Channel 6 command in [Scaling submenu](#) of the [Monitor menu](#). Depending on the scaling method selected in [Graph Preferences](#), either the coefficient and offset, or values at y=0 and at y=100 are displayed in the value field of a setting. The coefficient and offset are displayed as a formula in form *coefficient * x + offset*. The values at y=0 and y=100 are displayed within brackets ([]), separated with comma. Double-clicking the name of a setting presents user a Channel Scaling dialog box. [Changes](#) the coefficient and the offset, which are used to scale the measured value of the monitored item before it is drawn in the [trend display pane](#).

Datalogger	
Setting	Value
 Status	Running, Initialized
 Triggered by	
 Interval (ms)	10
 Pre-Trig (ms)	2300
 Trig Conditions	Fault, External
 Trig Variable	104.01: FC DUT...
 Trig Level	90
 Trig Hysteresis	4.999995
 X Axis Length (s)	10.000
 Y Axis Maximum	100.00
 Y Axis Minimum	-100.00
 01.02: SPEED...	$1.00 * x + 0.00$
 Channel 2	$1.00 * x + 0.00$
 Channel 3	$1.00 * x + 0.00$
 Channel 4	$1.00 * x + 0.00$
 n/a	
 n/a	

Datalogger settings display settings of the current datalogger, and consist of the following:

- Status shows the state of the datalogger. Double-clicking the name of the setting is same as Status Refresh toggle in the [Datalogger menu](#). Double-clicking [toggles](#) it on-line/off-line. Also Triggered by is toggled, if current datalogger has not been uploaded. On-line status is indicated by yellow background of the value.
- Triggered By shows the triggering reason. If the datalogger has not been uploaded, double-clicking the name of the setting is same as double-clicking the Status [setting](#). On-line status is indicated by yellow background of the value.
- Interval, same as Interval command in the [Datalogger menu](#). Double-clicking the name of the setting presents an Interval dialog box, where you can change the logging [interval](#) of the current datalogger.
- Pre-Trig (ms), same as Pre-Trig (ms) command in the [Trig Settings submenu](#). Double-clicking the name of the setting presents a Pre-Trig dialog box, where you can [change](#) the number of values kept in the current datalogger before the triggering event. The value is given and shown as time, but the datalogger actually uses a count.
- Trig Conditions, same as Conditions command in the [Trig Settings submenu](#). Double-clicking the name of the setting presents a Triggering Conditions dialog box, where you can change the [conditions](#), which trigger the current datalogger.
- Trig Variable, same as Variable command in the [Trig Settings submenu](#). Double-clicking the name of the setting presents a Trig Variable dialog box, where you can [change](#) OPC address of the variable, which is used in triggering the current datalogger. Note that the OPC address is given without channel and node, and the name used by the drive, not the OPC address, is shown in the value field.
- Trig Level, same as Level command in the [Trig Settings submenu](#). Double-clicking the name of the setting presents a Trig Level dialog box, where you can change the [triggering level](#), which is used in triggering the current datalogger.
- Trig Hysteresis, same as Hysteresis command in the [Trig Settings submenu](#). Double-clicking the name of the setting presents a Trig Hysteresis dialog box, where you can change the triggering level [hysteresis](#), which is used in triggering the current datalogger.
- X Axis Length, same as X Length command in the [Axis submenu](#) of the [Datalogger menu](#). Double-clicking the name of the setting presents an X Axis Length dialog box, where you can change the [x-axis length](#) of the datalogger graph at current zooming level, if any.
- Y Axis Maximum, same as Y Axis Maximum command in the [Axis submenu](#) of the [Datalogger menu](#). Double-clicking the name of the setting presents a Y Axis Maximum dialog box, where you can change the [y-axis maximum](#) value of the datalogger graph at current zooming level, if any.
- Y Axis Minimum, same as Y Axis Minimum command in the [Axis submenu](#) of the [Datalogger menu](#). Double-clicking the name of the setting presents a Y Axis Minimum dialog box, where you can change the [y-axis minimum](#) value of the datalogger graph at current zooming level, if any.
- Channel 1, ... Channel 6, same as Channel 1, ... Channel 6 command in [Scaling submenu](#) of the [Datalogger menu](#). Depending on the scaling method selected in [Graph Preferences](#), either the coefficient and offset, or values at y=0 and at y=100 are displayed in the value field of a setting. The coefficient and offset are displayed as a formula in form $coefficient * x + offset$. The values at y=0 and y=100 are displayed within brackets ([]), separated with comma. Double-clicking the name of a setting presents user a Channel Scaling dialog box. [Changes](#) the coefficient and the offset, which are used to scale the measured value of the logged item before it is drawn in the [trend display pane](#).

AC Drives for Drilling Applications

DriveWindows – Menu Commands

Data Logger Menu



AC Drives for Drilling Applications

DriveWindows – Data Logger Legend

Image Status



Off-line and not locked



On-line and not locked, background of the value is also yellow



Off-line and locked



On-line and locked, background of the value is also yellow

1

Monitored in channel 1

2

Monitored in channel 2

3

Monitored in channel 3

4

Monitored in channel 4

5

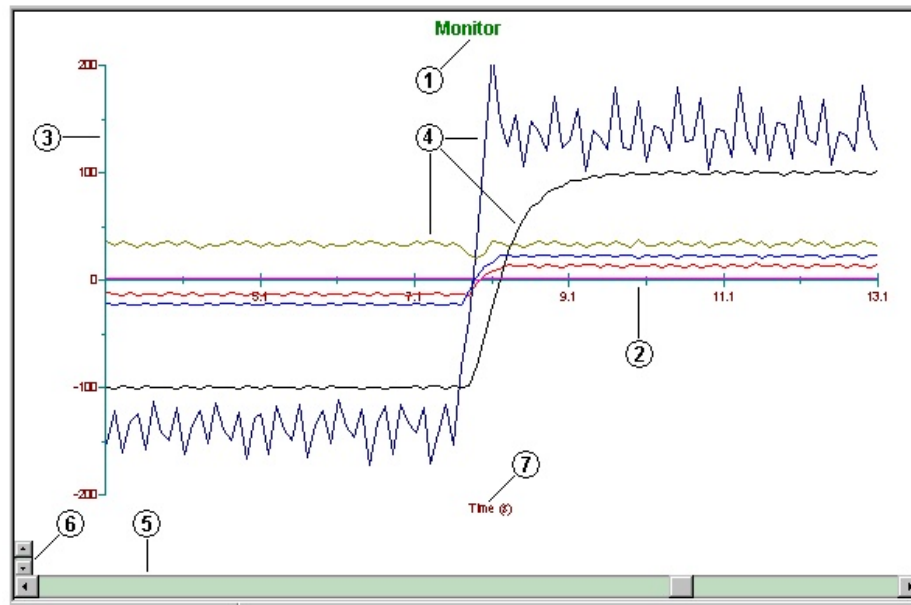
Monitored in channel 5

6

Monitored in channel 6

AC Drives for Drilling Applications

DriveWindows – Trend Window

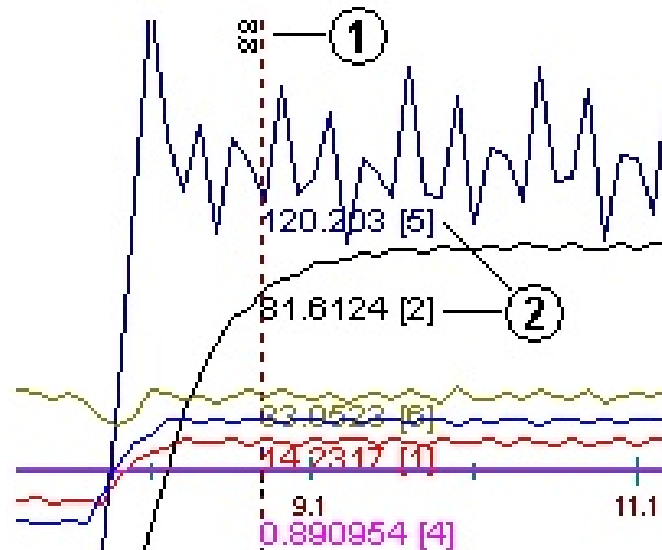


The trend display pane contains the following:

1. Title, which indicates, what is currently displayed (monitor or datalogger and which datalogger)
2. X-axis (the time axis). Its length can be set by user in the [trend settings pane](#) and also changed by zooming. You can scroll x-axis horizontally, if there are more values collected than are displayed. While monitoring, the x-axis scrolls in real time after the right end has been reached.
3. Y-axis. Minimum and maximum can be set by user in the [trend settings pane](#) and also changed by zooming. Minimum and maximum can also be changed by vertical scrolling.
4. The measured or logged trends.
5. Horizontal scroll bar, which is visible only when horizontal scrolling of the x-axis is possible.
6. Vertical scroll buttons. You can scroll the y-axis upwards and downwards.
7. X-axis label, always Time (s).

AC Drives for Drilling Applications

DriveWindows – Trend Cursors

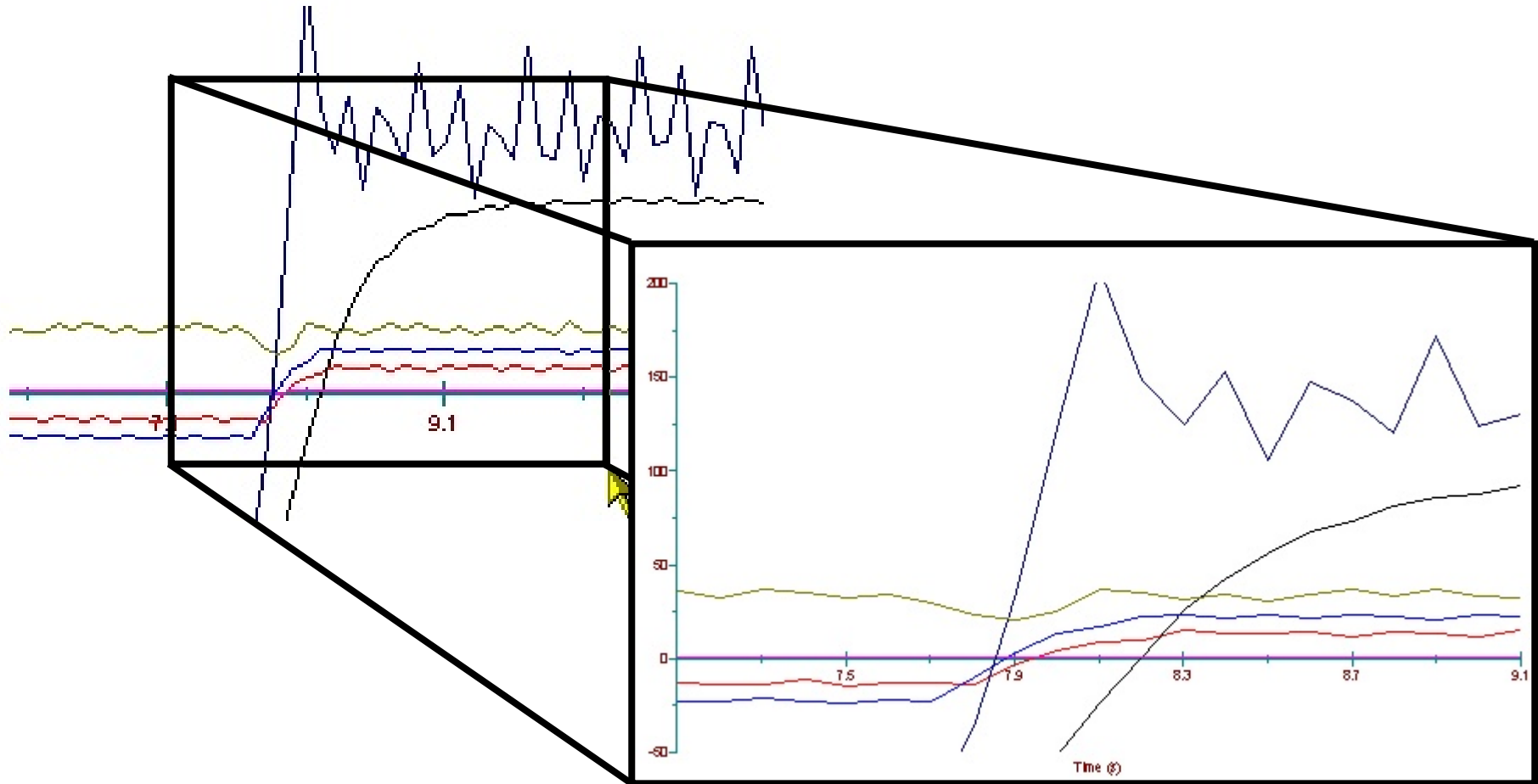


Depending on, whether scaled or unscaled values are to be shown, the cursor is either a dotted (scaled values) or dashed (unscaled values) vertical line with the following numerical values:

1. Time at the point of the cursor (written vertically).
2. For each trend, value at the point of cursor, and the channel number within brackets (if there is more than one trend).

AC Drives for Drilling Applications

DriveWindows – Trend Zoom



AC Drives for Drilling Applications

PPO – Data Groups

- PPO Data Field Structure

Process Data: Master to Slave

Control Word		Reference Value 1		Process Data 1		Process Data 2		Process Data 3		Process Data 4		Process Data 5		Process Data 6		Process Data 7		Process Data 8	

Process Data: Slave to Master

Status Word		Actual Value 1		Process Data 1		Process Data 2		Process Data 3		Process Data 4		Process Data 5		Process Data 6		Process Data 7		Process Data 8	

AC Drives for Drilling Applications

PPO Data – PLC Commands

- Control Word Structure (Master to Slave)

Bit	Description	
	Value = 0	Value = 1
0	STOP 1 (by ramp)	ON 1
1	STOP 2 (by coast)	ON 2
2	STOP 3 (by ramp)	ON 3
3	RUN DISABLE	ENABLE
4	No Action	START
5	No Action	START
6	No Action	START
7	No Action	FAULT RESET (0->1)
8	No Action	No Action
9	No Action	No Action
10	Disable Profibus Control	Enable Profibus Control
11	Fieldbus DIN1=OFF	Fieldbus DIN1=ON
12	Fieldbus DIN2=OFF	Fieldbus DIN2=ON
13	Fieldbus DIN3=OFF	Fieldbus DIN3=ON
14	Fieldbus DIN4=OFF	Fieldbus DIN4=ON
15	Fieldbus DIN5=OFF	Fieldbus DIN5=ON

AC Drives for Drilling Applications

PPO Data – Inverter Information

■ Status Word Structure (Slave to Master)

Bit	Description	
	Value = 0	Value = 1
0	Not Ready (initial)	READY
1	Not Ready	READY
2	DISABLE	ENABLE
3	NO FAULT	FAULT ACTIVE
4	STOP 2 OFF	STOP 2 ON
5	STOP 3 OFF	STOP 3 ON
6	START ENABLE	START DISABLE
7	No Warning	Warning
8	Reference $\neq$ Actual value	Reference = Actual
9	Fieldbus control OFF	Fieldbus control ON
10	Not Used	Not Used
11	Not Used	Not Used
12	FC Stopped	Running
13	FC not ready	FC ready
14	Not Used	Not Used
15	Not Used	Not Used

AC Drives for Drilling Applications

Communications Board – References

■ Status Word Structure (Slave to Master)

Bit	Description	
	Value = 0	Value = 1
0	Not Ready (initial)	READY
1	Not Ready	READY
2	DISABLE	ENABLE
3	NO FAULT	FAULT ACTIVE
4	STOP 2 OFF	STOP 2 ON
5	STOP 3 OFF	STOP 3 ON
6	START ENABLE	START DISABLE
7	No Warning	Warning
8	Reference $\neq$ Actual value	Reference = Actual
9	Fieldbus control OFF	Fieldbus control ON
10	Not Used	Not Used
11	Not Used	Not Used
12	FC Stopped	Running
13	FC not ready	FC ready
14	Not Used	Not Used
15	Not Used	Not Used

AC Drives for Drilling Applications

PPO Data - References

■ Reference Value One

- Typically this is the Speed Reference
- Range is from -10000 to +10000
 - 10000 is equal to 100.00% Reverse Speed
 - 0 is equal to stop (0.00% Forward Direction)
 - +10000 is equal to 100.00% Forward Direction

■ Actual Value One

- Typically this is the Inverter Speed Feedback
 - Range is from -10000 to +10000
 - 10000 is equal to 100.00% Inverter Speed in Reverse
 - +10000 is equal to 100.00% Inverter Speed in Forward
- The PLC will scale this accordingly for Display and control

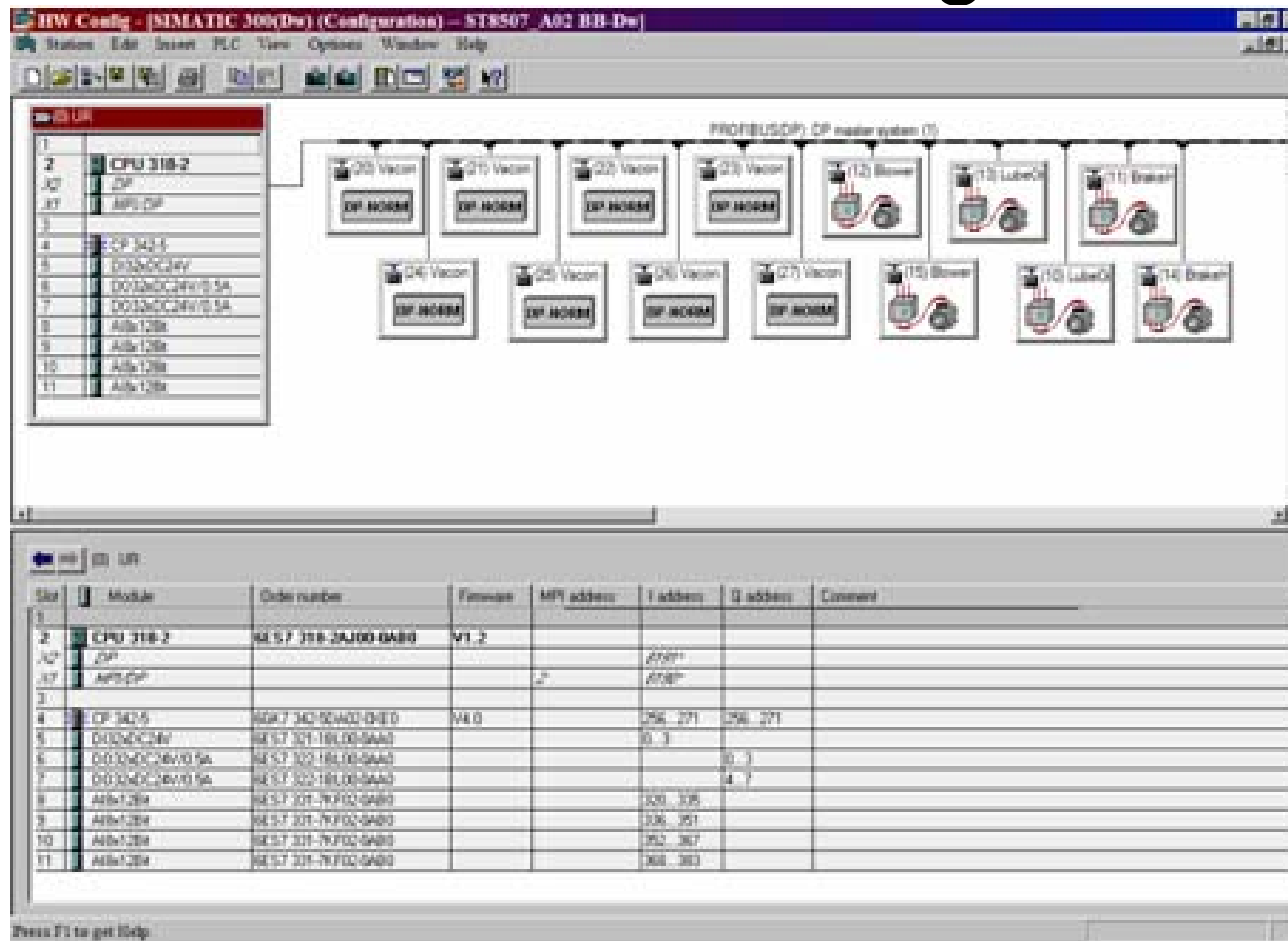
AC Drives for Drilling Applications

PPO Data - Groups

- **Process Data – Master to Slave**
 - PD1 – PD8 (Process Data words 1-8)
 - Control Information
 - Contains both Digital and Analog Values
- **Process Data – Slave to Master**
 - PD1 – PD8 (Process Data words 1-8)
 - Status Information
 - Contains both Digital and Analog Values

AC Drives for Drilling Applications

PLC Hardware Configuration



AC Drives for Drilling Applications

PLC program elements

- OB Organization Block
- Function Calls
- Function Blocks
- Data Blocks
- User Defined Tables
- System Function Calls
- System Function Blocks

AC Drives for Drilling Applications

PLC program elements

■ OB Organization Block

- Main Program Elements designed to control the PLC Program
- Controls CPU Functions
- Handles Program errors
- Handles Hardware error detection

■ Function Calls

- Software that performs the users operations
- Can be written in Ladder Logic, Statement List, and Function Block Diagram
- Varies depending upon equipment and desired result

■ Function Blocks

- User defines the Function Block
- Contains its own data storage area
- Usually used to perform calculations used over and over
- Requires a Data Block to store variables

AC Drives for Drilling Applications

PLC program elements

■ Data Blocks

- Preset memory storage of data
- Can be accessed by multiple types of software blocks
- Used to store data to go across networks
- Can handle multiple forms of data

Discrete	Timer Data
Counters	Bytes
Words	Integers
Double Words	Double Integers
Real or Floating Point Numbers	

■ User Defined Tables

- Similar in function to a Data Block
- Difference is the programmer determines the structure
- Set to define programming sequence

AC Drives for Drilling Applications

PLC program elements

■ System Function Calls

- Prewritten code devised to perform a specific function
- Typically “Know How Protected”, code cannot be accessed
- Some come preloaded into the CPU
- Some devices require the installation of some SFCs

■ System Function Blocks

- Similar to Function Blocks
- Prewritten code devised to perform a specific function
- Typically “Know How Protected”, code cannot be accessed
- Some come preloaded into the CPU
- Has its own Data Storage
- Requires a Data Block to store variables

AC Drives for Drilling Applications

PLC program elements

■ Data Blocks from the Drive

- DB## (Typically DB80) is Status Information from the Inverter
- Inverter Controller writes data to this Data Block
- Cannot alter this data to affect the Drive Operation

■ Data Blocks to the Drive

- DB## (Typically DB81) is control Information from the Inverter
- Control signals such as Start, Stop, Speed, etc..
- Levels and Signals come from program execution in the PLC
- PLC Writes to this Data Block
- PLC can and will alter this data

AC Drives for Drilling Applications

PLC program elements

■ Data Blocks Declaration View

- Used for programming
- Used to edit the data
- Defines default values

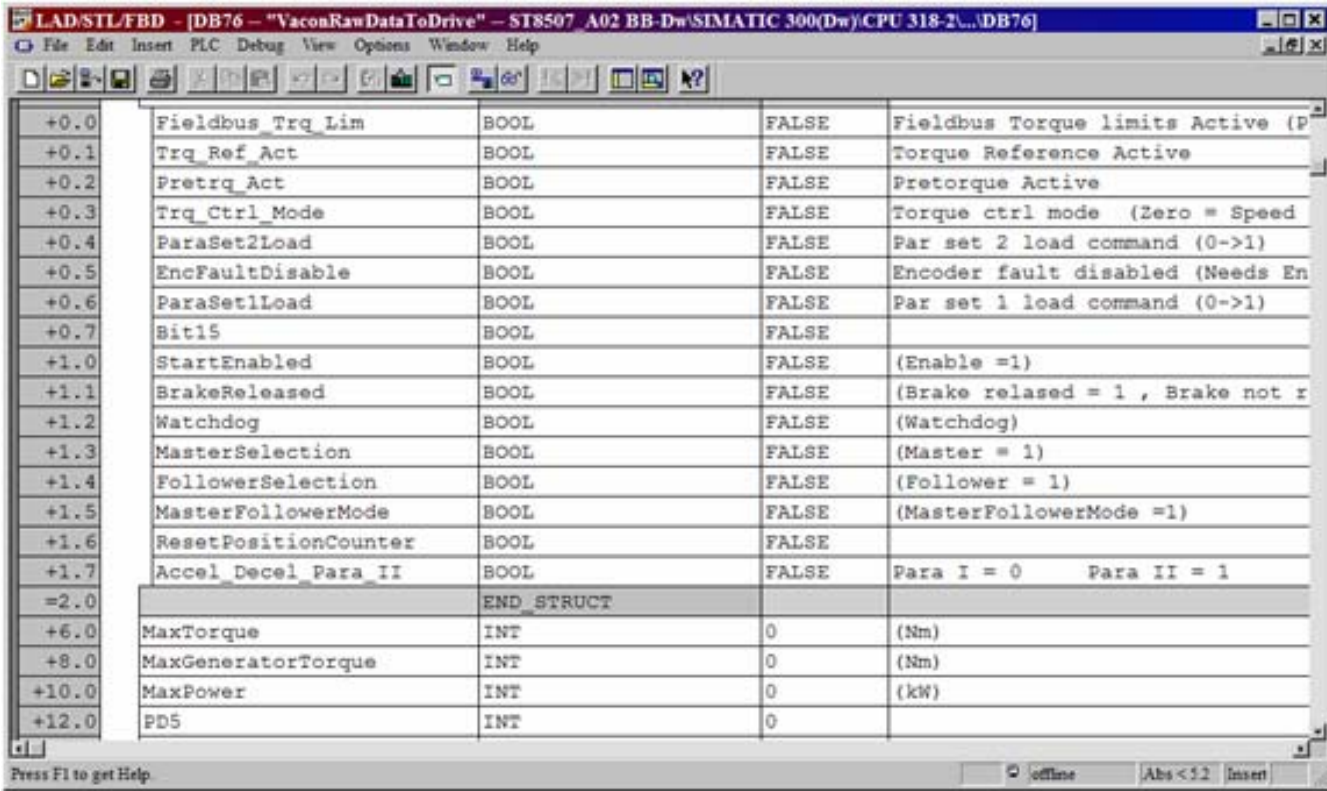
■ Data Blocks Data View

- Used to monitor the values within the Data Block
- Use this to troubleshoot signals coming from and going to the Inverter
- Cannot change the data
- Cannot change the default values
- Can be accessed from the 'View Menu'

AC Drives for Drilling Applications

PLC program elements

- Data Blocks Declaration View



LAD/STL/FBD - [DB76 - "VaconRawDataToDrive" - ST8507_A02_BB-Dw/SIMATIC 300(Dw)/CPU 318-2\...\DB76]				
File Edit Insert PLC Debug View Options Window Help				
+0.0	Fieldbus_Trq_Lim	BOOL	FALSE	Fieldbus Torque limits Active (P
+0.1	Trq_Ref_Act	BOOL	FALSE	Torque Reference Active
+0.2	Pretrq_Act	BOOL	FALSE	Pretorque Active
+0.3	Trq_Ctrl_Mode	BOOL	FALSE	Torque ctrl mode (Zero = Speed
+0.4	ParaSet2Load	BOOL	FALSE	Par set 2 load command (0->1)
+0.5	EncFaultDisable	BOOL	FALSE	Encoder fault disabled (Needs En
+0.6	ParaSet1Load	BOOL	FALSE	Par set 1 load command (0->1)
+0.7	Bit15	BOOL	FALSE	
+1.0	StartEnabled	BOOL	FALSE	(Enable =1)
+1.1	BrakeReleased	BOOL	FALSE	(Brake relased = 1 , Brake not r
+1.2	Watchdog	BOOL	FALSE	(Watchdog)
+1.3	MasterSelection	BOOL	FALSE	(Master = 1)
+1.4	FollowerSelection	BOOL	FALSE	(Follower = 1)
+1.5	MasterFollowerMode	BOOL	FALSE	(MasterFollowerMode =1)
+1.6	ResetPositionCounter	BOOL	FALSE	
+1.7	Accel_Decel_Para_II	BOOL	FALSE	Para I = 0 Para II = 1
=2.0	END_STRUCT			
+6.0	MaxTorque	INT	0	(Nm)
+8.0	MaxGeneratorTorque	INT	0	(Nm)
+10.0	MaxPower	INT	0	(kW)
+12.0	PD5	INT	0	

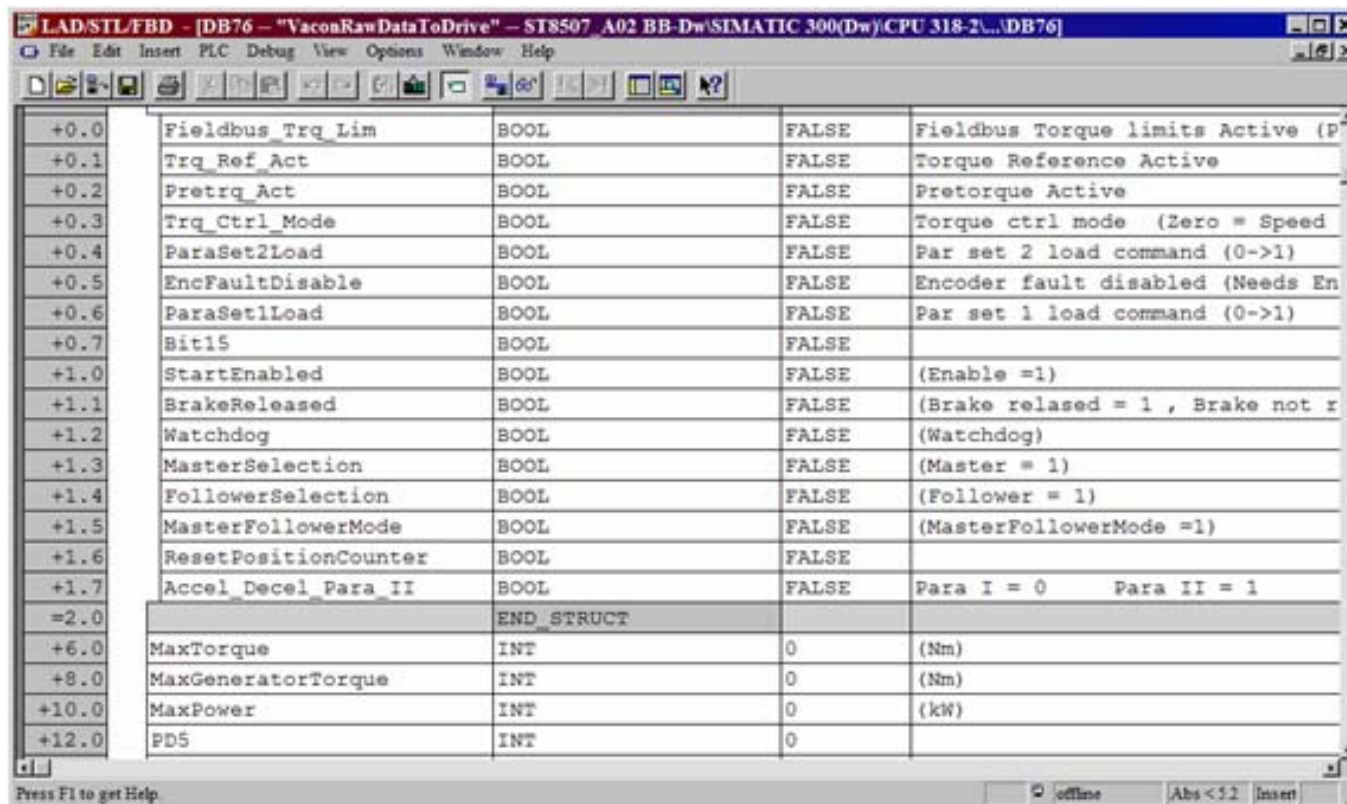
Press F1 to get Help

offline Abs < 12 Insert

AC Drives for Drilling Applications

PLC program elements

- Data Blocks Data View



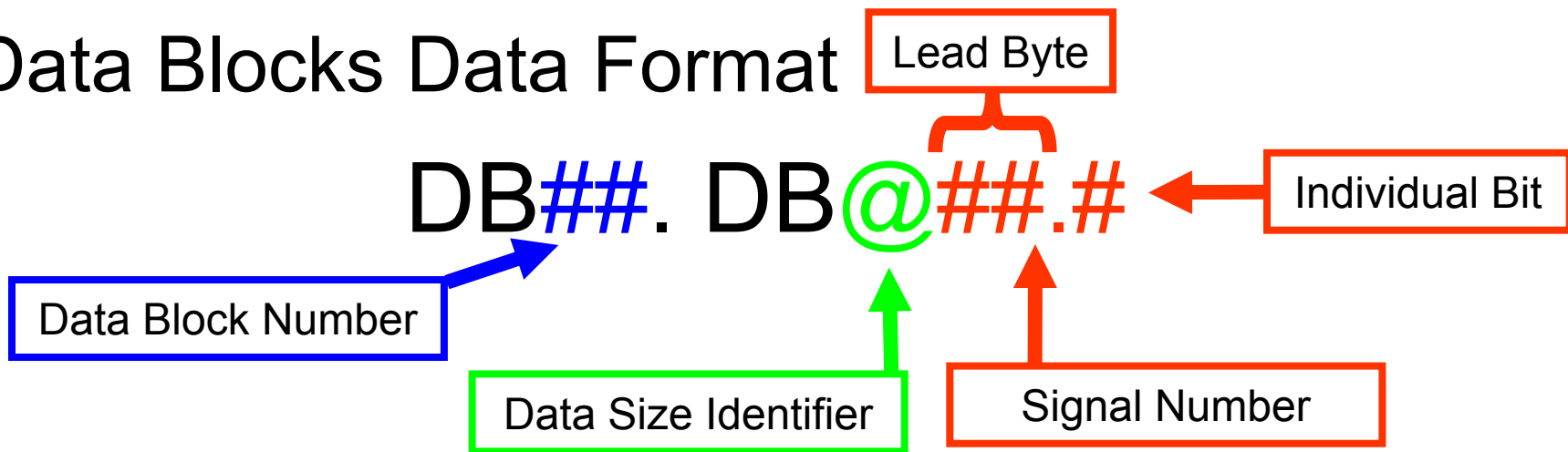
The screenshot shows the SIMATIC Manager Data View for a data block named 'VaconRawDataToDrive'. The table lists various parameters and their values.

Address	Variable Name	DataType	Value	Description
+0.0	Fieldbus_Trq_Lim	BOOL	FALSE	Fieldbus Torque limits Active (P
+0.1	Trq_Ref_Act	BOOL	FALSE	Torque Reference Active
+0.2	Pretrq_Act	BOOL	FALSE	Pretorque Active
+0.3	Trq_Ctrl_Mode	BOOL	FALSE	Torque ctrl mode (Zero = Speed
+0.4	ParaSet2Load	BOOL	FALSE	Par set 2 load command (0->1)
+0.5	EncFaultDisable	BOOL	FALSE	Encoder fault disabled (Needs En
+0.6	ParaSet1Load	BOOL	FALSE	Par set 1 load command (0->1)
+0.7	Bit15	BOOL	FALSE	
+1.0	StartEnabled	BOOL	FALSE	(Enable =1)
+1.1	BrakeReleased	BOOL	FALSE	(Brake relased = 1 , Brake not r
+1.2	Watchdog	BOOL	FALSE	(Watchdog)
+1.3	MasterSelection	BOOL	FALSE	(Master = 1)
+1.4	FollowerSelection	BOOL	FALSE	(Follower = 1)
+1.5	MasterFollowerMode	BOOL	FALSE	(MasterFollowerMode =1)
+1.6	ResetPositionCounter	BOOL	FALSE	
+1.7	Accel_Decel_Para_II	BOOL	FALSE	Para I = 0 Para II = 1
=2.0	END_STRUCT			
+6.0	MaxTorque	INT	0	(Nm)
+8.0	MaxGeneratorTorque	INT	0	(Nm)
+10.0	MaxPower	INT	0	(kW)
+12.0	PD5	INT	0	

AC Drives for Drilling Applications

PLC program elements

■ Data Blocks Data Format



Data Size identifiers

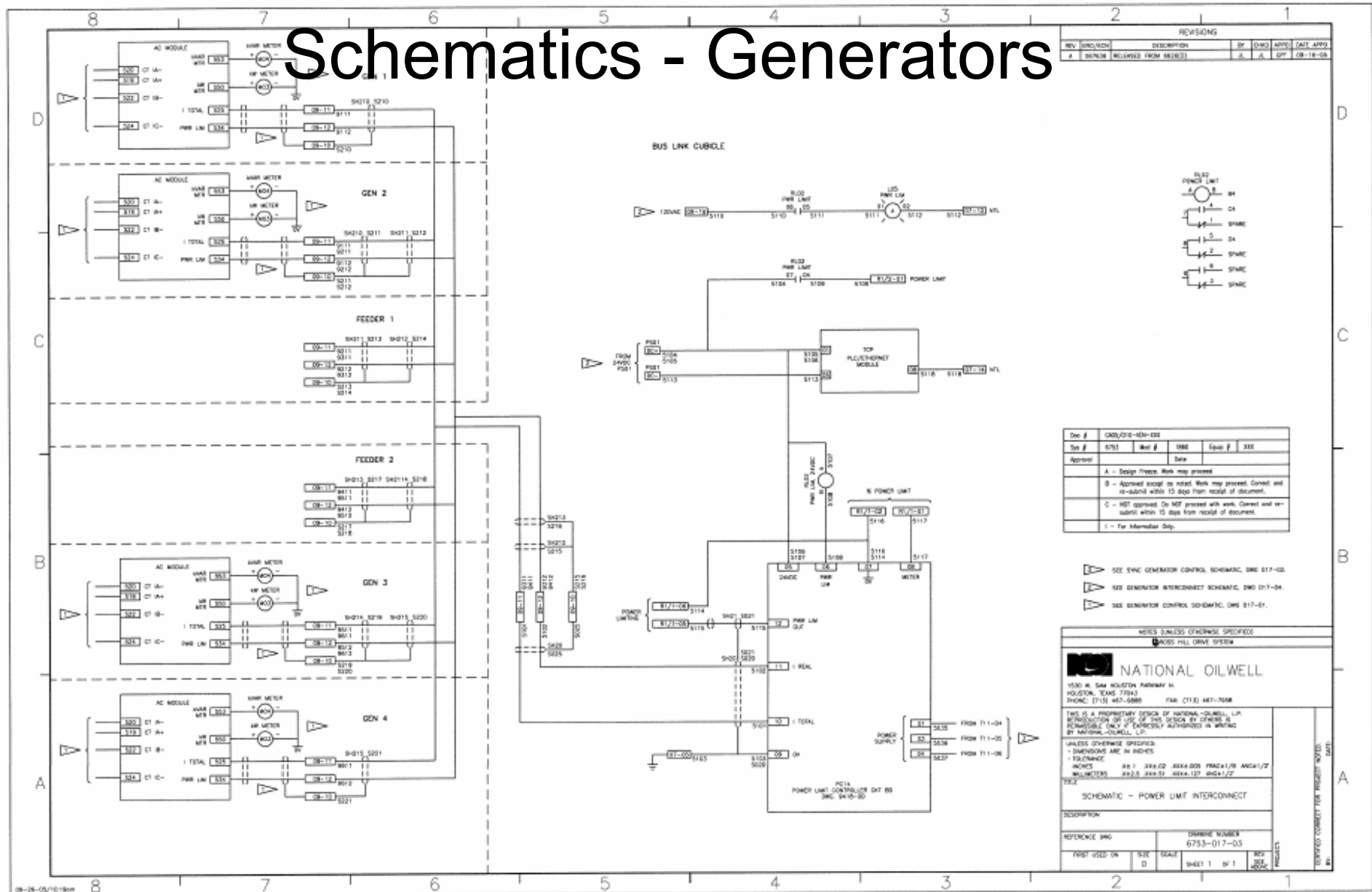
X = Bit Level

B = Byte level

W = Word Level

D = Double Word Level

Schematics - Generators

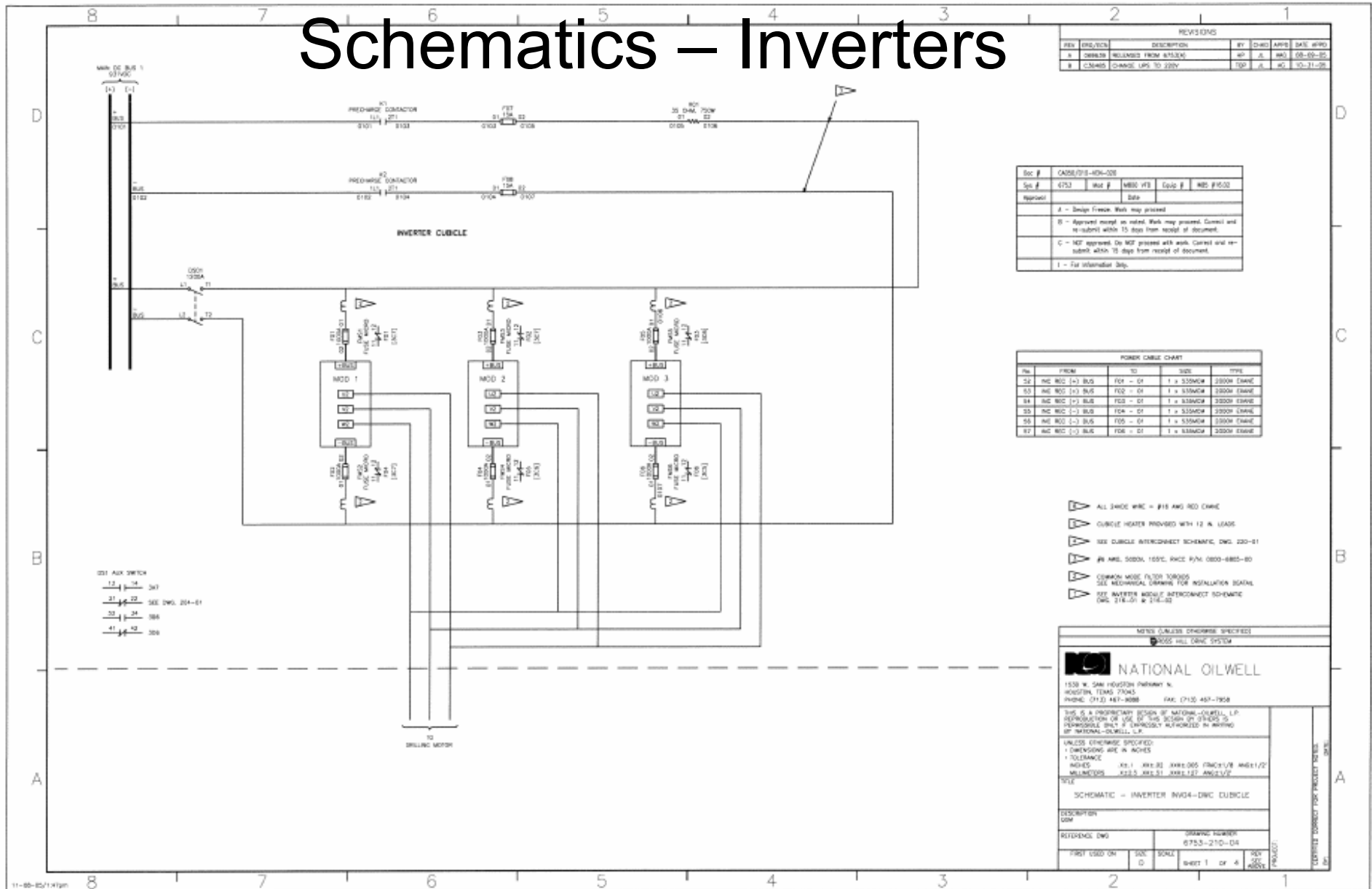


Schematics – Incomers/Rectifiers



AC Drives for Drilling Applications

Schematics – Inverters



Schematics – Choppers



AC Drives for Drilling Applications

Water Cooling Connections



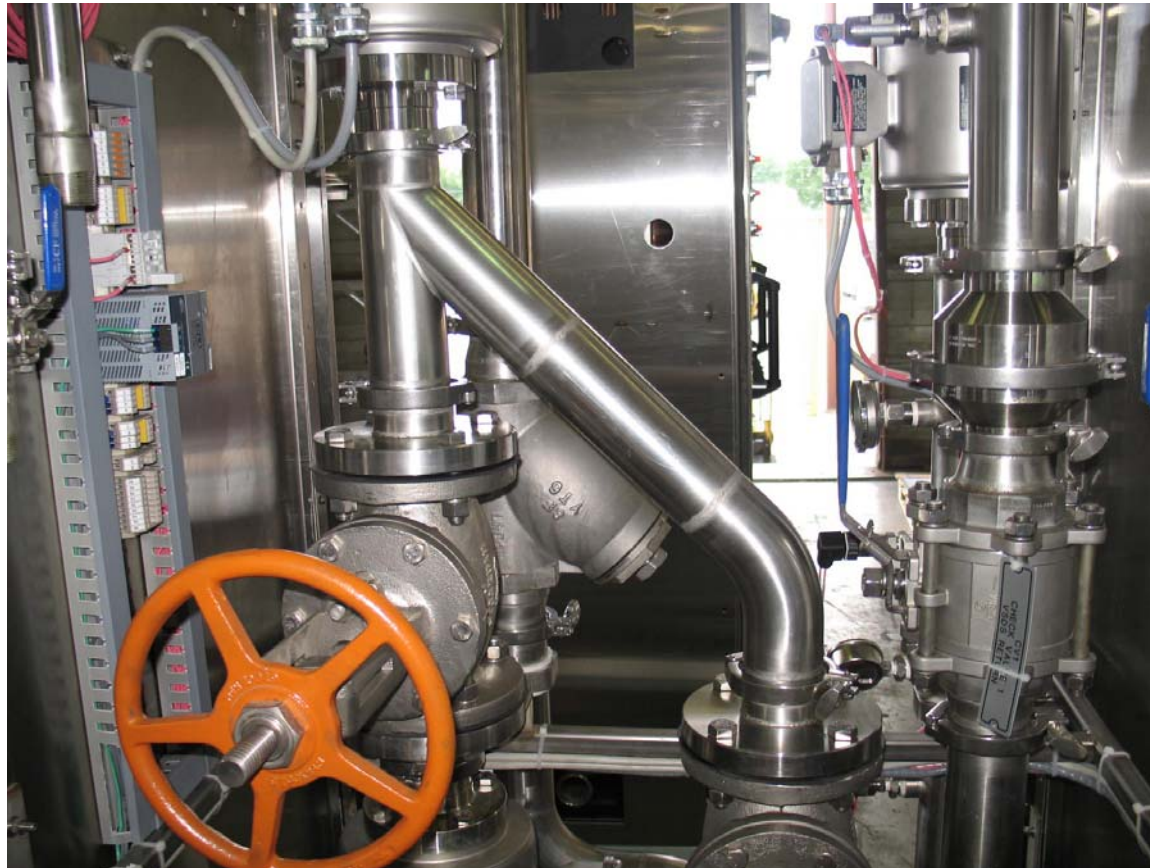
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Cooling System



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Flow Meter



AC Drives for Drilling Applications

ESD

- **ESD Generation**
- **Damages Caused By ESD**
- **Preventative Measures**

AC Drives for Drilling Applications

ESD

- Bringing Materials Together
- Rubbing Materials Against Each Other
- Rapid Separation Of Two Materials
- Placing Materials Close To Each Other

The size of the charge is dependent of the speed of separation, humidity and materials used.

AC Drives for Drilling Applications

Means Of Static Generation	Voltage Levels	
	10-20% Humidity	65-90% Humidity
Walking Across Carpet	35,000	1,500
Walking Across Vinyl Floor	12,000	250
Common Poly Bag Picked Up From Bench	20,000	1,200
Common Sandwich Bag Or Styrofoam Cup	20,000	1,200
Work Chair Padded With Polyurethane Foam	18,000	1,500
Worker At Work Bench	6,000	100

AC Drives for Drilling Applications

ESD Voltage Levels

Voltage Level Needed To Feel & Hear	3,000 Vdc
Voltage Level Needed To Damage Printed Circuit Boards	250 Vdc
Voltage Level Needed To Damage The Gate Lead Of An IGBT	25 Vdc

AC Drives for Drilling Applications

Types Of ESD Failures

Catastrophic - The component fails

Latent - The component is stressed and functions some of the time and will stop functioning in the future (after hours or when your on vacation)

AC Drives for Drilling Applications

Field Precautions For ESD

ESD Wrist Strap

To be worn when ever installing or removing printed circuit boards from drive with power disconnected.

To be worn when ever handling components that have been shipped in black conductive containers.

Test your wrist strap regularly.

Environment

- Temperature
 - Altitude
 - Humidity
 - NEMA 1, 12
 - De-Ratings

Temperature, Altitude & Humidity

- In general, all drives are rated at 32 - 104 degrees “F” (0-40 degree “C”)
- In general, all drives are rated up to 3300 ft. ASL
- In general, all drives are rated up to 95% relative humidity, non-condensing

De-Ratings

- - All drives can be de-rated up to a maximum of 122 degrees “F” (50 degrees “C”)
- - All drives can be de-rated up to 13,123 ft.

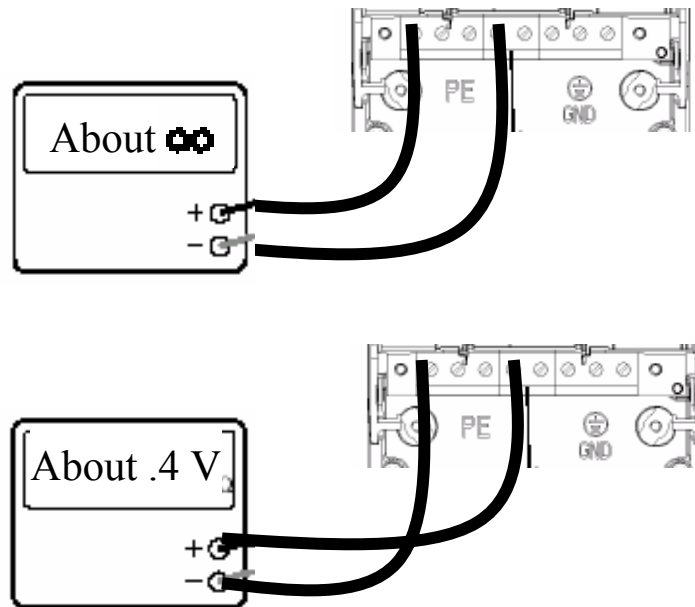
Hardware Manual Pg. 70

Equipment Required & Readings

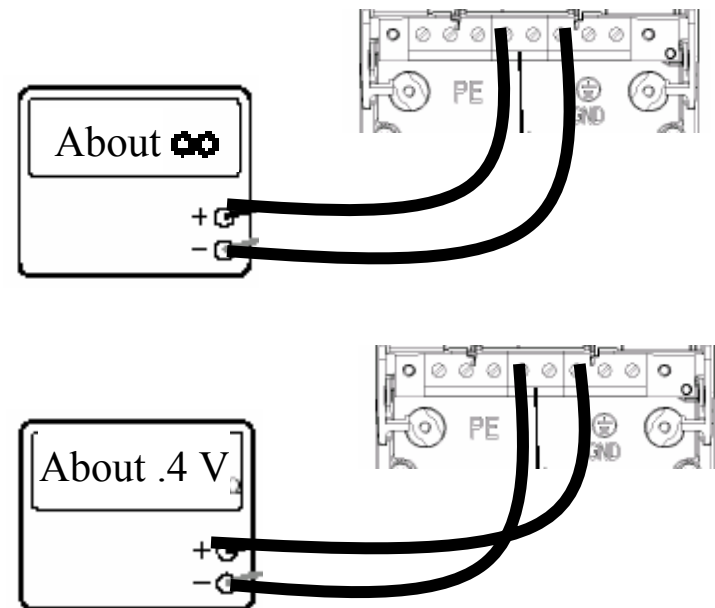
- ***Megger***
- **Multimeter**
- **Clamp-On-Ammeter**
- **Static Checks (ohmmeter)**

Static Measurements

- Diode Bridge Check
Diode Scale (All 3 Phases)
Measure from Input Term's:
to + Bus, (Both Directions)
to - Bus, (Both Directions)



- Output (IGBT) Test -
Diode Scale (All 3 Phases)
Measure from Output Term's:
to + Bus, (Both Directions)
to - Bus, (Both Directions)

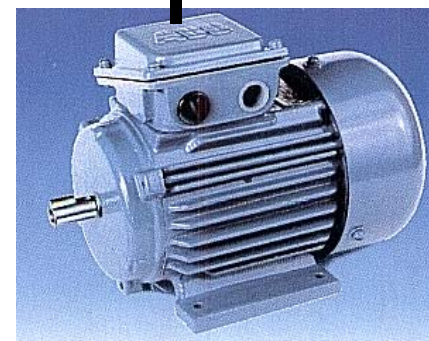
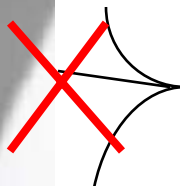


Megger Measurements



Megger each motor lead to ground with leads disconnected from drive. All (3) readings should be in the high Megohm.

Ensure motor leads are re-connected to motor output terminals !!!



“800” - *Control Wiring*

Refer to the Hardware manual and connection diagrams for cabling

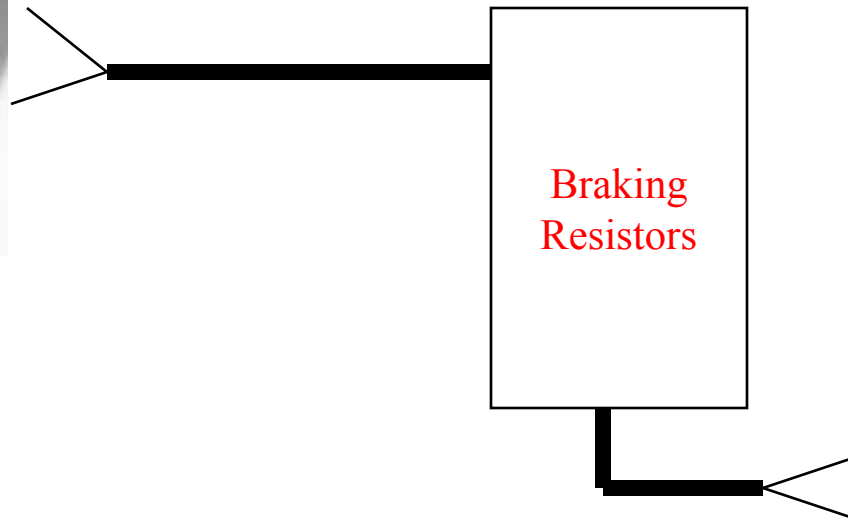
Note: Separate conduit for all control wiring, if indicated)

Use shielded Control cable

Dynamic Braking



Note: Braking Chopper Must Be Enabled In Programming
And Voltage Limit Disabled. Enter Resistor Ohm,
Watts And Time Constant For Resistor Protection Ckt.



Braking Resistor
Thermistor Should Be
Wired To Input Contactor
Coil (hardware manual)

Braking Requirements

- Cable distance between drive and resistors should be no more 10Meters
- Safety control circuit, resistor temp sensors
- Caution on surface temperature of resistor package
- Turn off over voltage limit parameter
Brake Chopper control set by Group 27

Note: Refer to braking manual for braking duty cycles, mounting and wiring requirements

Input Power Wiring

- All drives require minimum 60 C copper wire, size per NEC
- All drives must have separate metallic conduit for input, control and output power wiring
- Avoid parallel runs of power and control wiring. Input power wiring to cross control wires at 90 degrees
- When installing drives inside other enclosures, ensure 8" spacing between power and control wires or use shielded power cable
- When installing drives inside other enclosures, ensure 20" spacing between motor and control wires or use shielded motor cable

Note: Refer to the Hardware manual for wire type and requirements

Output Power Wiring

- Use minimum 60 C copper power wiring, size per NEC
- Must use separate metallic conduit for input, control and output wiring
- Output motor wiring can also be type MC continuous corrugated armor cable
- For drive sizes 490 KVA and larger, MC continuous corrugated armor cable is highly recommended
- Be aware of long cable lengths and their effect on the motor's insulation system

Note: Refer to the Hardware manual for wire type and requirements

Before Applying Power - CAUTIONS

- Ensure Power Source (690V) Matches Drive's Rating
- If Drive Uses EMC Filters, Ensure Power Source Is A Grounded Source. If Floating, Remove EMC Capacitor Ground. Contact ABB Tech Support For Assistance
- Ensure Drive's Internals Are Free From All Foreign Matter
- Ensure Motor Lead Are Connected To Motor Terminals And Main Power Is Connected To Input Terminals
- Ensure Motor Is Capable Of Running Mechanically

Safety Issues

- Never Work Alone
- Use (1) Hand During Start-Up (*As Much As Possible*)
- Remove all Loose-fitting Clothing, Jewelry, Metal Items
- NO ESD wrist straps when power is applied
- Approach Any Drive as if it were “Live”
(Buss voltage discharge - check)
- Output phase to ground voltage
 - phase to phase
 - phase to ground
- Lock-Out procedures

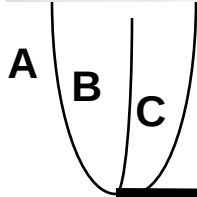
Note: ALWAYS measure AC input power and DC buss voltage before working on drives

Drive Programming

- ID Run (first start, reduced, standard)
- Auto Speed Tune
- Customer's Set Up – Verify that Drive OL is “ON” without Dynamic Braking
- Option Module Programming (I/O, Comm, AP, etc.)
- Upload To Keypad, Save to User Save 1

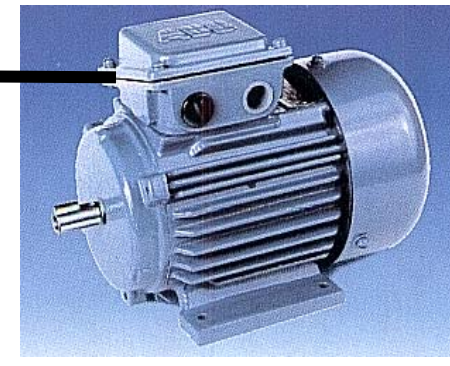
Input Voltage Readings

Multimeter Voltage Measurements

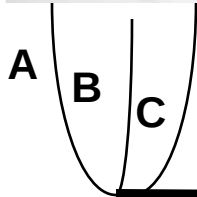


With the drive running at full speed and full load, measure AC input and motor output phases A-B, A-C, B-C. All input readings should be within approx. 2-3 % of each phase combination. Output voltage should be within nominal motor name plate level.

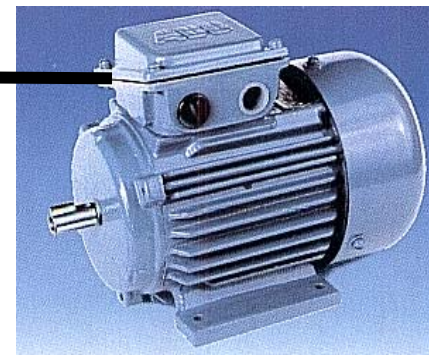
Note: Before applying power to drive, ensure voltage level is within drives input voltage rating.



Output Voltage Readings



With drive running at full speed and full load, measure all (3) AC input and all (3) motor output phases to ensure both drive and motor are within their nameplate ratings. All phases should be within approx. 5% of each other.



Faults And Warnings

When encountering drive warnings or faults during the start up, refer to the drive's Firmware Manual for evaluation

- Drive's fault memory
- When running DTC, drive can not be run without a motor, use Scalar mode

Before leaving the job site, ensure all warnings and faults have been deleted from memory

AC Drives for Drilling Applications

PLC Checks

- Determine the problem in the Function Calls
- Use the Data Blocks to verify a PLC Problem
- If you need to monitor multiple signals use the Variable Tables
- Keep in mind that the PLC uses Bits, Bytes, Words and Double Words
- You can use the Hardware Diagnostics to Help you in troubleshooting the network

AC Drives for Drilling Applications

Bridge Removal



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AC Drives for Drilling Applications

Bridge Removal

Removal and installation of the module by 'rolling-in' using auxiliary ramp plate



AC Drives for Drilling Applications

Maintenance Schedule

This table lists the routine maintenance intervals recommended by ABB.

Maintenance	Interval	Instructions
Capacitor reforming	Every year when stored	See <i>Capacitor reforming</i> .
Heatsink temperature check and cleaning	Depending on the dustiness of the environment, every 6 to 12 months	See <i>Heatsinks</i> .
Cabinet air filter check; replacement if necessary	Every year	See <i>Checking and replacing the air filters</i> .
Frame R4i and R5i inverter modules: Change of additional cooling fan	Every 3 years	See <i>Cooling fans</i> .
Frame R8i inverter modules: Check and cleaning of power connections	Every 4 years	See <i>Power connections (R8i)</i> .
Cooling fan change	Every 5 years	See <i>Cooling fans</i> .
Frame R4i and larger inverter modules: capacitor renewal	Every 10 years	See <i>Capacitors</i> .

AC Drives for Drilling Applications

Maintenance - Capacitors

The drive intermediate circuit employs several electrolytic capacitors. Their lifespan is from 45,000 to 90,000 hours depending on drive loading and ambient temperature. Capacitor life can be prolonged by lowering the ambient temperature.

It is not possible to predict a capacitor failure. Capacitor failure is usually followed by a mains fuse failure or a fault trip. Contact ABB if capacitor failure is suspected.

Replacements are available from ABB. Do not use other than ABB-specified spare parts.

Capacitor reforming

Reform (re-age) spare part capacitors once a year according to *ACS 600/800*

Capacitor Reforming Guide (code: 64059629).

AC Drives for Drilling Applications

Maintenance - LEDs

This table describes LEDs of the drive.

Where	LED	When the LED is lit
RMIO board *	Red	Drive in fault state
	Green	The power supply on the board is OK.
Control panel mounting platform	Red	Drive in fault state
	Green	The main +24 V power supply for the control panel and the RMIO board is OK.

* the LEDs are not visible in frame sizes R2i to R5i

AC Drives for Drilling Applications

Maintenance - Fans

Cooling fans

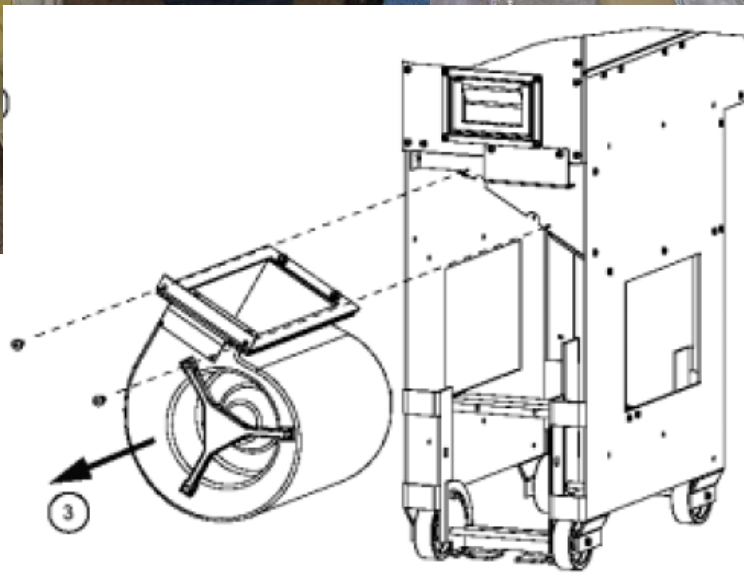
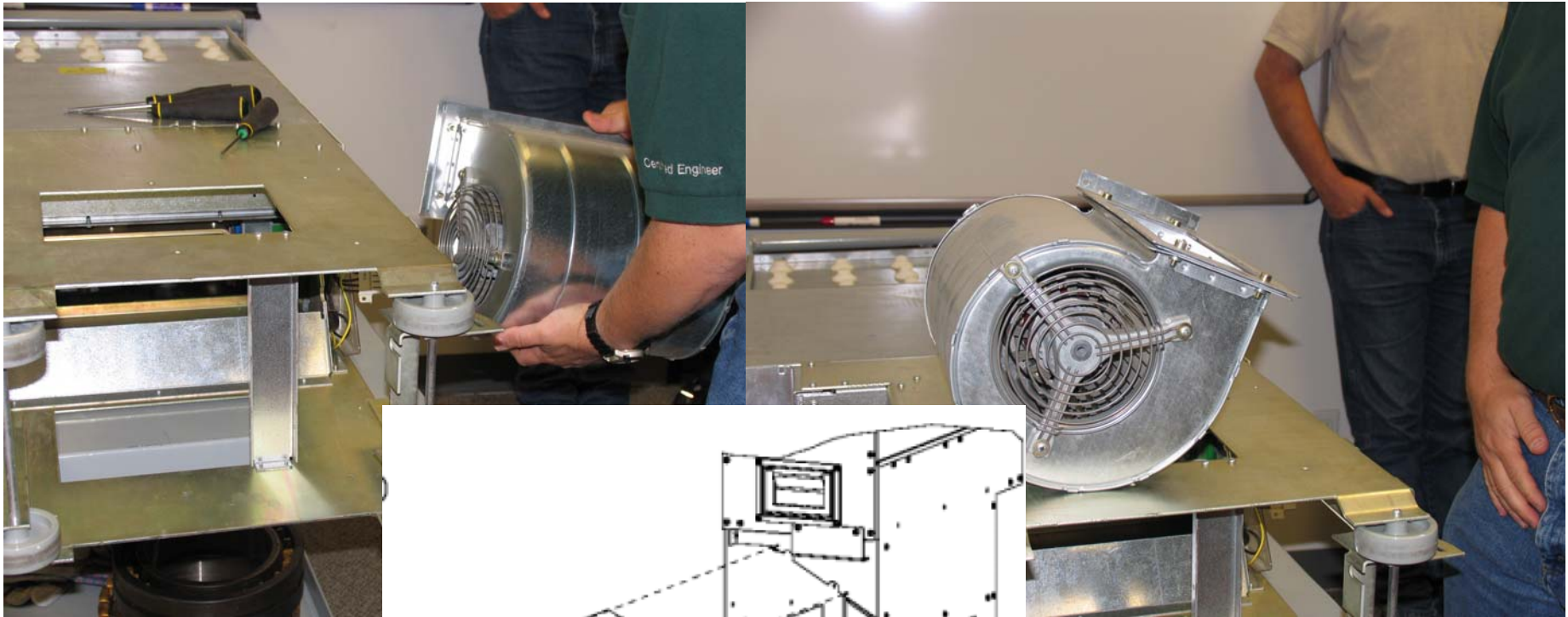
The cooling fan lifespan is about 60 000 operating hours. The actual lifespan depends on the drive usage and ambient temperature. See the appropriate ACS 800 firmware manual for an actual signal which indicates the hours of usage of the fan. Fan failure can be predicted by the increasing noise from fan bearings and the gradual rise in the heatsink temperature in spite of heatsink cleaning. If the drive is operated in a critical part of a process, fan replacement is recommended once these symptoms start appearing. Replacement fans are available from ABB. Do not use other than ABB-specified spare parts.

Fan replacement (R8i)

1. Open the inverter cubicle doors.
2. Disconnect the fan wiring plug.
3. Remove the locking screws.
4. Pull the fan out along its sliding rails.
5. Install a new fan in reverse order.

AC Drives for Drilling Applications

Maintenance - Fans



Training Solutions

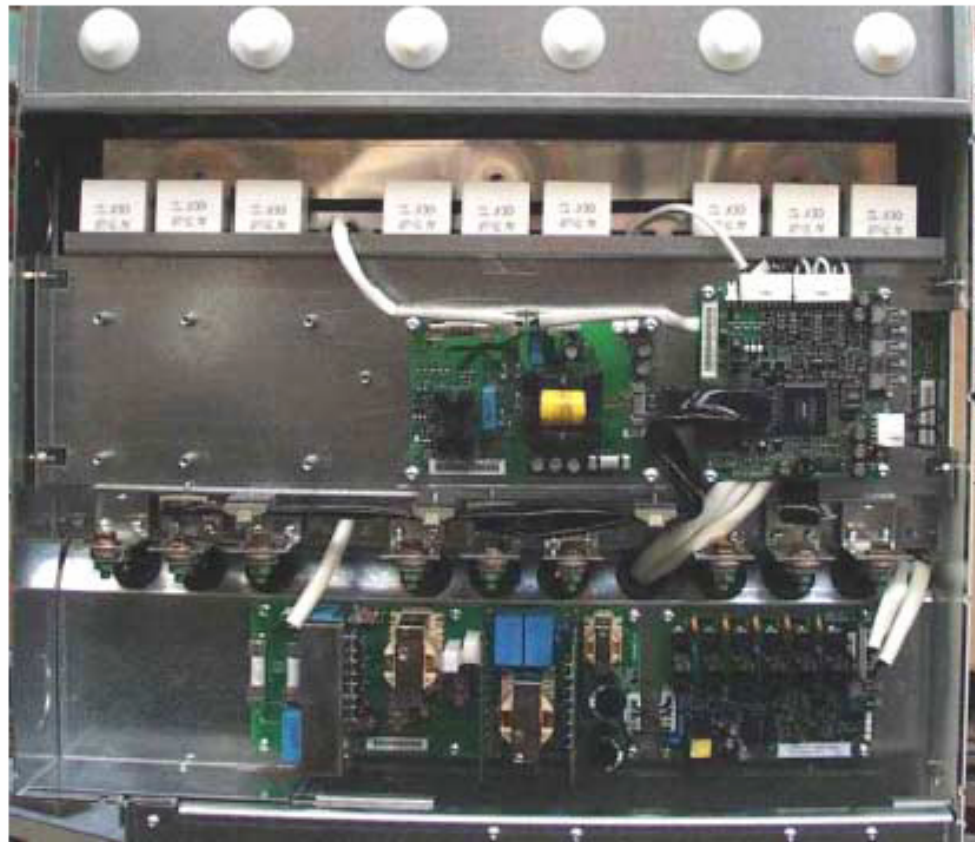
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AC Drives for Drilling Applications

Maintenance - Assembly

On the left side of the module, open eight screws to remove cover. The Cover is fastened with 4x8 screws and tightening torque is 2,4Nm. Under the cover is mounting plate for the APOW and AINT.



Picture 1. Mounting plate for Power Supply Card and Main Circuit Interface Board. Below the mounting plate is INU for fan. Mounting plate is fastened with four 4x16 Torx screws and Serpress M4 nut.

AC Drives for Drilling Applications

Maintenance - Assembly



Picture 2. Disconnect the wire from AINT-12C connector X7 and pull it away from under the board. Also disconnect cables coming from the AGPS boards.

AC Drives for Drilling Applications

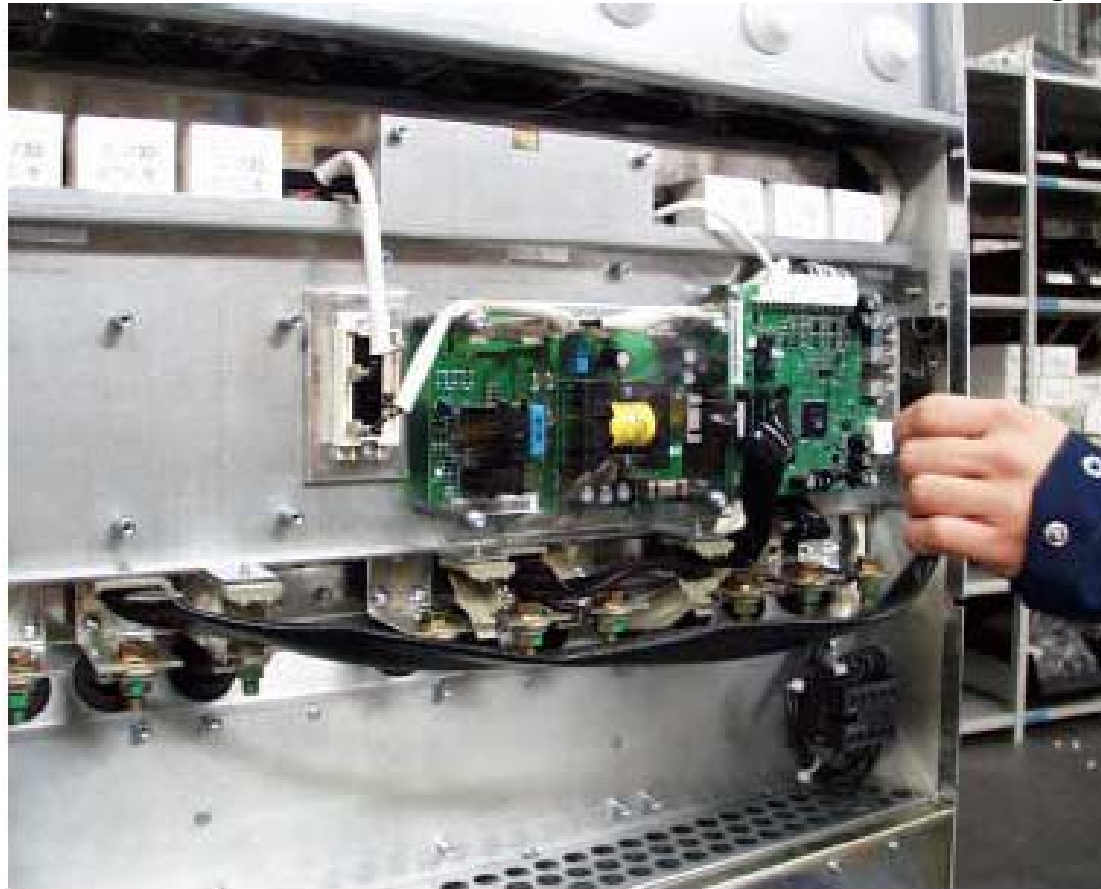
Maintenance - Assembly



Picture 3. Disconnect the DC wires from the NRED-61 thick-film hybrid

AC Drives for Drilling Applications

Maintenance - Assembly



Picture 4. Release cables from their holders under the mounting plate.

AC Drives for Drilling Applications

Maintenance - Assembly



Picture 5. After disconnecting mounting plate, cables from AGDR boards are hanging loose.

AC Drives for Drilling Applications

Maintenance - Assembly



Picture 6. Remove the capacitors and busbars connected to faulty IGBT module. They are fastened to modules with 8x12 Combi-Torx screws.

AC Drives for Drilling Applications

Maintenance – Assembly

If necessary, remove incoming cables from busbars. Cables are fastened with 8×25 screws and M8 nut.

Under the nut are two washers. Tightening torque is 16Nm.

Remove the faulty IGBT module and clean the heat sink surface with an appropriate solvent (e.g. Grafol) and a soft cloth from excess thermal compound and particles. IGBT module is fastened to heatsink with M5×20 Combi-Torx screws. Also check inside of the inverter module for foreign objects.

When placing a new IGBT module, follow the instructions written in chapter three (Installation of Econopack+ in ACS800 inverters) of this maintenance instruction.

Install the rest of the components in reverse order.

AC Drives for Drilling Applications

Maintenance – Assembly

INSTALLATION OF ECONOPACK+ IN ACS800 INVERTERS

1. Clean the contact surface of heatsink.
2. Clean the contact surface and the terminals of IGBT-module. Check that the contact surface is not damaged.
3. Apply a thin and uniform layer of thermal grease (typ. thickness 50 –100 µm) to whole contact area of IGBT-module with a roller or a rubber spatula. Amount of grease is sufficient when bright contact surface of IGBT-module is not visible through the grease. Check visually that there are no foreign particles among the spread grease.
4. Place a module to heatsink by hand and press it about 5 sec. Repeat phases 1 - 4 to every IGBT-module before the next phase.
5. All the M5 screws must be tightened uniformly to specified mounting torque. For a good thermal contact to the heatsink we recommend the following procedure of tightening the 8 screws:
 - Tighten module to heatsink with M5 screws to a pretightening torque (0,5 Nm) in the following sequence: screw no. 2 – 6 – 3 – 7 – 4 – 8 – 1 – 5. (Figure 1)
 - Tighten screws to final tightening torque (3 - 6 Nm) in the same sequence:

AC Drives for Drilling Applications

Maintenance – Assembly

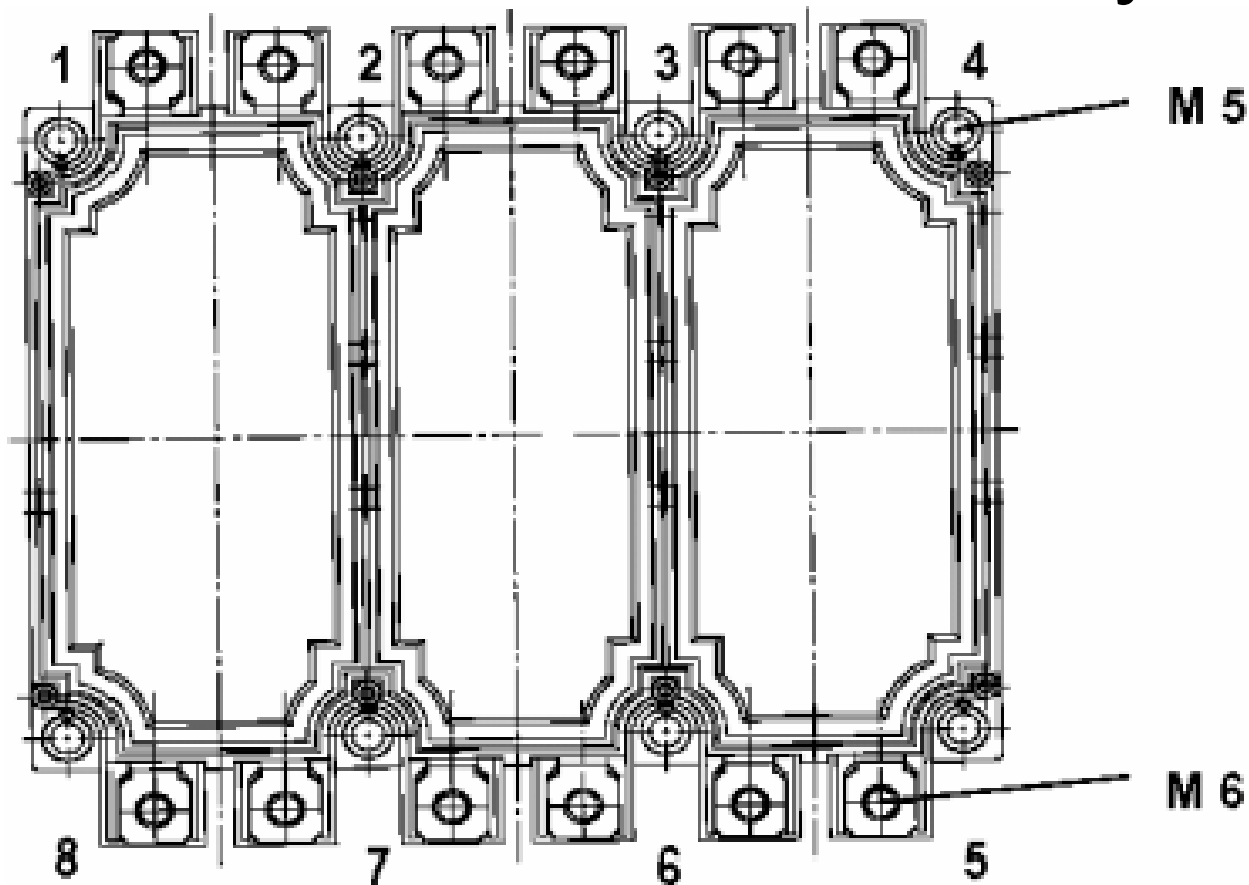


Figure 6. The screwing sequence and sizes.

AC Drives for Drilling Applications

Maintenance – Assembly

After the tightening a small rim (1 – 4 mm) of grease must be seen around the mounted module. This shows that amount of grease is sufficient. Extra grease is wiped away.

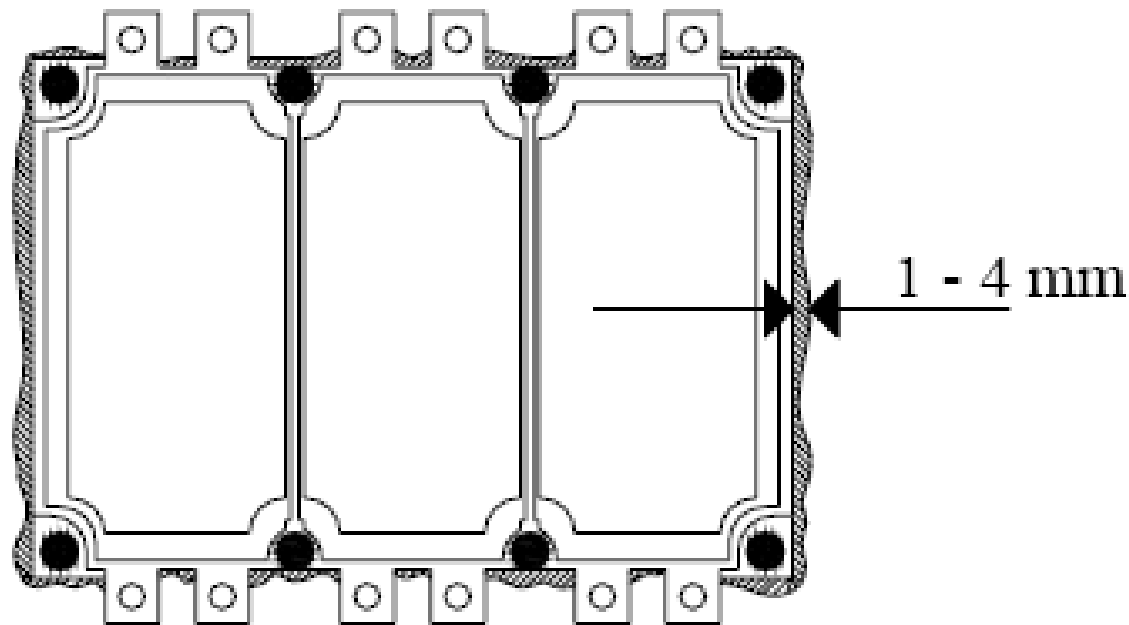


Figure 7. A rim of grease around the module.

Busbars are connected to power terminals of IGBT-module with M6 screws. Tightening torque is 3 Nm.